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Advanced Public Transportation Systems for Rural Areas: Where Do We Start? How Far Should We Go?

Prepared for:

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The project Principal Investigator was Anna M. Nalevanko, Director, the Transit Operations Group at ITRE. Ms. Nalevanko, along with Andrew Henry, ITRE Research Associate, were the primary authors of the study Final Report and guidance document. John Sajovec of TransCore and Kenneth Hosen of the KFH Group were the lead staff from their respective firms and contributed to concept development, writing chapters of the Interim Report and Final Report, and review and comments on study deliverables. Dr. John Stone, Civil Engineering Department at North Carolina State University, contributed to concept development and provided review and comments. Thomas J. Cook, ITRE Senior Research Associate, conducted research, developed the draft taxonomy, and provided review and comments.

Many transit managers and professionals generously contributed their time and knowledge to this report by hosting visits to case study sites, participating in detailed telephone interviews, and providing valuable written materials related to transit technology selection, planning and implementation. They are too numerous to name, but many of their names appear in the detailed case study materials. The authors are also appreciative of the time and advice that the TCRP Topic Panel earnestly contributed. The willingness to contribute to this research demonstrates a positive spirit among those in the transit community to kindly share their resources and knowledge.

EXECUTIVE SUMMARY

Background

The overall goal of this study is to review the state of Advanced Public Transportation Systems (APTS), and to determine how far transit should go in implementing new technologies in rural and small urban areas. The objectives of this study are to:

- Provide a framework to assist rural and small urban transit systems in conducting a cost/benefit analysis;
- Determine how rural and small urban public transit systems can benefit from cooperative arrangements;
- Document the findings in a final comprehensive report; and,
- Develop a decision guide to aid in the selection, procurement, and implementation of APTS technologies that are appropriate to the size and needs of the transit system.

The decision guide will be published as a companion document to this report. The guide was designed to capture the information from this final report and compile the data into an easy to navigate guidance document for transit operators.

The purpose of this final report is to:

- Present an approach to determine APTS applicability;
- Identify technology system implementations in rural transit systems;
- Identify integrated highway and public transit efforts in jointly supporting technology infrastructures;
- Summarize findings from a telephone survey of APTS sites;
- Present the findings from visits to six case study sites;
- Present a taxonomy or process to evaluate transit technology;
- Present measures of effectiveness to evaluate how well advanced technology solutions meet rural transit needs; and,
- Provide information on financing technology capital costs.

State of the Practice

Data were gathered first through preliminary telephone contacts with a total of 25 rural and small urban transit operators. These interviews were brief and were intended to capture some basic operational data and an understanding of technology implementation issues.

To obtain greater insights into implementation choices and issues, 13 of the 25 sites were then included in a more detailed telephone survey. The 13 sites were selected to include: various service types, operations sizes, and geographic regions, plus a representative mix of technology types implemented.

Figure 1 (3.2 in the report) lists the 25 rural APTS sites contacted and presents information on their technology installed.

Figure 1: Small Urban and Rural APTS Sites: Implementation Status

Transit System	Technologies Implemented	Status	Explanation (new direction/ future plans)
Aiken County Council on Aging	• AIM software (Saber Corp.) – 1997 • Bar code scanners and odometers – 1997	Operational	Bar code scanners and odometers are installed on 15 vehicles. Automatically collect trip data from vehicles. Significantly reduced personnel data entry time. GIS to be developed and used for planning.
Arc Transit, Inc.	• Automated DRT (custom) - 1997 • Magnetic Stripe Fare Cards (test on 13 vehicles) – 1997 • AVL (test on 13 vehicles) - 1997	Changed direction and behind schedule	Planned expansion of fare cards and AVL to all vehicles by 1999 was delayed. Obtained funding for AVL. Arc is working with a neighboring county in a coordinated ITS cross-county system implementation.
Arrowhead Transit	• AVL and MDTs (American Mobile Satellite) – 1997 • Automated DRT software - 1997	Project terminated	Transit portion of project terminated. Vehicle/base station communication failed to meet accuracy and speed criteria.
Ben Franklin Transit	• DRT (FleetNet) fixed-route) – 1989 • Automated DRT software (PASS; paratransit) – 1995 • MDTs (Mentor) - 1999	Operational	FleetNet provides adequate scheduling despite being 10 years old. PASS has mitigated loss in efficiency with ridership changes from group to single trips.
BARTA	• Automated DRT software (MIDAS) – 1997	Operational	System has realized administrative benefits, but disappointed that software scheduling suggestions are frequently not helpful.
Blacksburg Transit	• Automated DRT software (IntelliTrans) - 1995	Changed direction	Planned AVL, variable message signs and dedicated cable channel. AVL server malfunctioning and no plans for repair. Technical difficulties threaten all components except DRT and variable message signs.
Cape Cod Regional Transit Authority	• Computer-assisted DRT software (developed in-house) – 1990 • AVL – 1999 • MDT (Mentor) – 1999 • Internet-based customer information system –1999	Behind schedule	Customized AVL test system failed. Rebid and installed new AVL/MDT system. Terminated DRT software contract, staying with in-house version with planned upgrade. Investigating Smart Card system. Enhancing real time vehicle location system via Internet. Installing digital radio system covering entire service area.
CARTS	• Automated DRT software (PASS) – 1995 • Digital radio system covering entire service area – 1998	Operational	Able to manage more vehicles, and reduced number of dispatchers and dispatch centers. Efficiency, cost, and service objectives accomplished. MDT installation planned.

Figure 1: Small Urban and Rural APTS Sites: Implementation Status (continued)

Transit System	Technologies Implemented	Status	Explanation (new direction/ future plans)
Citibus	• Electronic fareboxes (GFI) - 1996 • Automated DRT software (MIDAS) - 1999	Operational	System satisfied with fareboxes.
CATS	• GPS (Quest Track by Quest Systems) - 1998	Operational	Limited benefits, but planning to integrate with other technologies in the future.
Community Transit of Delaware County	• Computer-assisted DRT Software (Rides Unlimited) – 1996 • Automated Customer ID Program - 1998 • Wireless Data Communications System (Bell Atlantic "Air Bridge") - 1998 • MDT (Telxon) – 1999 • Web TV Reservation system – 1999	Operational, except, MDTs being installed	Very satisfied with DRT software in tracking both trip times and mileage. Further in-house customization to integrate DRT and RIMS software, and provide support to other Pennsylvania transit systems using product. Web TV demonstration program developed.
COAST	• Implementation Underway	Changed direction	Planned installation of automated DRT software and AVL. Key funding contract agency elected not to participate resulting in need to modify service plan, delaying implementation.
COLTS	• AVL (Auto-Trac) • MDTs (GMSI) • Smart Cards • Voice Annunciator (Digital Recorder)	No change	No new technology implementation planned.
DARTS	• Automated DRT software (PASS) – 1998	Operational	DRT software has not produced major improvements. Schedule recommendations are frequently overridden manually. Anticipate improvements following integration with MDT/AVL system (Mentor) within next year.
Delaware Transit Corporation	• Fareboxes (GFI) - 1980's • Video Cameras - 1980's • Automated DRT (PASS) - 1998 DR, 1999 FR	Operational	Works well, but had to correct many bugs in FR software. Provides good system analysis data. By end of 2000, new GFI fareboxes and infrared APCs, and planned upgrade to Motorola radio system with features similar to AVL and MDTs.
Flagler Senior Services	• Automated DRT (RouteLogic) – 1998 • AVL (Hyperdyne) – 1999	Operational	Some delay when key official from partner agency resigned.
FCRTA	• AVL Web-based vehicle tracking – 2000	Planned installation	Researching low-cost AT&T AVL system that utilizes cellular phones, satellites, and Internet to track vehicles.

Figure 1: Small Urban and Rural APTS Sites: Implementation Status (continued)			
Transit System	**Technologies Implemented**	**Status**	**Explanation (new direction/ future plans)**
KARTS	• Computer-assisted DRT software (MiniPASS) – 1996	Operational	DRT software has scheduling limitations, thus, plan installation of automated DRT software (ParaMatch) in 2000.
Laketran	• Automated DRT software (PASS) – 1993	Operational	PASS very efficient. Currently conducting procurement for MDT/AVL system (GMSI).
Mendocino Transit Authority	• Automated DRT software (PASS)	Operational	Functioning properly
Napa Valley Transit	• AVL (3M Infosystems) - 1995 • Signal Prioritization (3M Infosystems) - 1995 • Automatic Stop Annunciator (Digital Recorder) – 1997	Operational	All technology components have proven effective for scheduling efficiency and timeliness. Investigating installation of on-board video cameras.
Pierce Transit	• Fareboxes (GIF Cents-a-Bill) - 1990 • MDT (Mentor) for DR service – 1997 • GPS (Mentor) for DR service - 1997	Operational	Reevaluation of communications, and investigating MDTs, AVL, AVI (signal prioritization) on fixed-route buses.
STAR	• Computer-assisted DRT software (Rides Unlimited) – 1993	Behind schedule	Installed MDTs that use bar code readers and automated DRT software. Planned AVL and Smart Cards.
WSTA	• Automated DRT software (PASS) – 1995 • AVL - test on 3 vehicles – 1995 • MDTs (Mentor) – test on 3 vehicles – 1995 • Smart Cards - test on 3 vehicles – 1995	Behind schedule	DRT software upgraded to NT version. MDT, AVL, and Smart Card systems delayed.

The 13 in-depth interviews were designed to obtain greater insights into operational problems that could be addressed by advanced public transportation technology systems. The data obtained from these interviews helped to refine a draft taxonomy and to select those sites to be included in on-site interviews. These interviews were conducted at:

- Aiken Area Council on Aging, Aiken, South Carolina
- Arrowhead Transit, Virginia, Minnesota
- Ben Franklin Transit, Richland, Washington
- Berks Area Regional Transit Authority, Reading, Pennsylvania
- Blacksburg Transit System, Blacksburg, Virginia
- Cape Cod Regional Transit Authority, Dennis, Massachusetts
- Capital Area Rural Transit System, Austin, Texas
- Community Transit of Delaware County, Eddystone, Pennsylvania

- Flagler Senior Services, Palm Coast, Florida
- Fresno County Rural Transit Agency, Fresno, California
- Kaufman Area Rural Transportation, Terrell, Texas
- Kerr Area Rural Transit System, Henderson, North Carolina
- Sweetwater County Transit Authority, Sweetwater, Wyoming

The comprehensive interviews gathered more detailed data on each transit system and the technology implementation process. The data gathered was used in developing the taxonomy and selecting transit systems for case study visits.

Case Study Results

Case study sites represented a broad cross-section of services, technologies, and locations. The following criteria were used to select case study candidates:

- Use of different types of APTS, either singly or in combination
- Experience with and length of use of the installed technology(ies)
- Needs and functions that the technology is supporting
- Range of demographic characteristics, including geographic location, population size and density, and transit system size
- Variety of location characteristics including high/low growth, rural/metropolitan commute, tourist area, and single county/multi-county/regional service
- Desire of transit system staff and local officials to serve as case study participants
- Existence of data to contribute to the evaluation of the site as a case study

Based on these criteria, six case study sites were selected for detailed examination. Figure 2 (4.1 in the report) summarizes the relevant service and demographic characteristics of these sites.

Figure 2: Characteristics of Case Study Sites

System Name	Location and Region	Transit Service Area	Service Area and Population	Vehicles and Avg. Daily Trips	Technologies/ Years Implemented	Technologies Planned
Aiken County Council on Aging	Aiken, SC (Southeast)	Self-contained, low growth community rural tourist area	1,079 sq. miles; 132,000 (pop.)	15 vehicles; 304 FR, 69 DR	• Bar Code Identification, computer-assisted DRT software -- 3 years	• GIS • AVL
Arrowhead Transit	Virginia, MN (Midwest)	Large, sparsely populated rural area	20,000 sq. miles; 200,000 (pop.)	53 vehicles; 1,400 DR	• Automated DRT software, satellite communications, AVL, and MDT -- (project terminated)	No current plans
Cape Cod Regional Transit Authority	Dennis, MA (Northeast)	Rural to metropolitan area commute, rural tourist area	400 sq. miles; 200,000 (pop.)	100 vehicles; 250 to 1,110 FR, 700 DR	• Computer-assisted DRT software -- 10 years • GPS/AVL – 1 year (pilot test) • AVL via Internet -- 1 year • GPS/AVL -- < 1 year • MDTs -- < 1 year • Digital radio for entire service area -- current implementation	• Automated DRT software • Smart cards
Capital Area Rural Transit System (CARTS)	Austin, TX (Southwest)	High growth (small city plus nine counties); rural to urban commutes	7,500 sq. miles; 1,100,000 (pop.)	60 vehicles; 1,600 DR	• Automated DRT software -- 6 years • Digital and voice radio system -- 2 years	• MDTs

Figure 2: Characteristics of Case Study Sites (continued)						
System Name	**Location and Region**	**Transit Service Area**	**Service Area and Population**	**Vehicles and Avg. Daily Trips**	**Technologies/ Years Implemented**	**Technologies Planned**
Community Transit of Delaware County	Eddystone, PA (Northeast)	Slow/no growth, self-contained local community	185 sq. miles; 550,000 (pop.)	110 vehicles; 1,350 DR	• Computer-assisted DRT software -- 4 years • MDTs (pilot test) -- 2 years • CDPD wireless data communications -- 2 years • Automated customer identification program (pilot test) -- 1 year • Web TV reservation system (pilot test) -- 1 year • DRT s/ware service provider -- 1 year • MDTs, fleetwide -- < 1 year	• Automated DRT software
Flagler Senior Services	Palm Coast, FL (Southeast)	Self-contained high growth area	487 sq. miles; 110,000 (pop.)	16 vehicles; 350 DR	• Automated DRT software -- 2 years • AVL/GPS -- < 1 year	No current plans

Some common themes emerged from the case study sites that illustrate success factors, lessons learned, approaches to matching needs and technology, preferred order of product installation, and other characteristics of these transit technology leaders. The primary reason for implementing new technology at most case study sites was the desire to increase efficiency (and therefore reduce costs) and improve service quality. The case studies also clearly demonstrated the value of working in partnerships with state and local agencies, transit and human service providers and private interests. All the case study sites established a formalized technology planning process, and most sites had a committee involved in the planning. Other information from the case study sites emphasized the importance of:

- A phased approach to selecting, procuring, and installing technology(ies);
- Working with staff throughout the planning, procurement, and implementation process to reduce fear of a new technology and the consequential resistance to its use;
- Considering implementation of a technology product as not just a series of one-time installation tasks but an ongoing project;

- A dedicated project manager and champions;
- Quality and comprehensive training;
- Good support from the product vendors and expert integrator;
- An open system architecture and ample future expansion capabilities;
- Installing and mastering a technology infrastructure before moving to more specialized components;
- The development of a reliable mobile, or wireless, communication system;
- Seeking out solutions that meet your short-term and long-term budget; and
- Taking advantage of joint procurement opportunities.

Development of Recommended Taxonomy

Taxonomy is a classification based on relationships. The development of a taxonomy for this study looked at relationships among key characteristics of rural and small urban transit systems. Those characteristics included transit system size, transit system operating characteristics, and needs of various users. The taxonomy serves as a tool to assist in the selection and implementation of technology solutions to meet the needs and address the operational problems of transit managers, operations staff, contracted agencies, and the customer.

The study team utilized the information gathered from the telephone interviews and visits to case study sites to refine the taxonomy dimensions that were initially developed in the earlier phases of this study. This taxonomy is to serve as a guide to transit operators in selecting and implementing appropriate technology systems.

The project team believes that the taxonomy should use system size as a primary dimension, specifically fleet size. Growth potential (in fleet and number of passenger trips) should also be taken into consideration when defining the size of a transit system. This dimension of the taxonomy involves classification into one of three major types of rural transit systems—small, medium, or large—defined as follows:

1. Small rural transit system—operating fewer than 10 peak vehicles
2. Medium rural transit system—operating between 10 and 30 peak vehicles
3. Large rural transit system—operating more than 30 peak vehicles

These numbers are approximate and were generated through study team deliberation and findings from the literature review and interviews with transit systems.

Another primary dimension is transit system needs. The consideration of needs is important because ITS technologies should only be implemented to meet identified needs and solve problems related to those needs. For this taxonomy, the needs are presented from the perspective of transit system management because they have primary responsibility for determining the appropriateness and applicability of ITS technologies.

In addition to transit system size and needs, attention should also be focused on several secondary discriminators. These secondary discriminators include type of service operated, number of agencies served, type of riders (human service agency or general public), number of daily riders (passenger trips), number or percentage of demand-responsive trips, and size of area served. Although these secondary discriminators do not represent a dimension through which the taxonomy is organized, they are an important influence in determining technology choices. For example, although the number of vehicles is a primary discriminator for selecting the use of MDTs, the type of service, e.g., demand-responsive, also has an important influence and therefore is noted in the taxonomy. Figure 3 (5.3 in the report) offers brief descriptions of the technologies used in the taxonomy.

Figure 3: Technology Descriptions

Technology	Use	Acronym	Description/Purpose
Automatic Passenger Counter	Fixed-Route	APC	Counts current number of passengers boarding and alighting vehicle; calculates vehicle load after pullout
Automatic Vehicle Location	Fixed-Route & Demand-Responsive	AVL	Determines vehicle location from using navigation sensors (usually GPS), commonly sending position data to base station via radio or other communication link
Accounting Software	Fixed-Route & Demand-Responsive	No acronym	Electronically processes, stores, tracks and reports standard accounting data and processes
Communications	Fixed-Route & Demand-Responsive	No acronym	Provides voice and/or digital communication among vehicles and base stations. Radio uses variety of private and commercial systems, frequency bands, and technologies. Cellular offers several commercial providers.
Customized Spreadsheet and Databases	Fixed-Route & Demand-Responsive	No acronym	Allows user to develop a computer software application to store, manipulate and report on any desired set of data such as that related to clients, schedules, trips, and billing
Demand -Responsive Transit Software *Automated*	Demand-Responsive	DRT	Expedites call taking, automatically schedules trips and routes vehicles, collects and maintains client, service and vehicle data, generates standard and customized reports
Demand-Responsive Transit Software *Computer-Assisted*	Demand-Responsive	DRT	Expedites call taking, prepares driver manifests, collects and maintains client, service, and vehicle data, and generates standard and customized reports
En-route Customer Information	Fixed-Route	No acronym	Provides real-time travel information to transit passengers and transit vehicle operators while traveling, e.g., variable message signs

Figure 3: Technology Descriptions (continued)

Technology	Use	Acronym	Description/Purpose
Fare Media – Bar Codes – Magnetic Stripe – Smart Cards	Fixed-Route & Demand-Responsive	No acronym	Allows payment of fares without cash; cards with bar code or magnetic strip deducts fare from cash value of card; smart card deducts fare from cash value stored on embedded microchip and transfers cash value from account at bank machine or equivalent
Geographic Information Systems	Fixed-Route & Demand-Responsive	GIS	Computer application that displays and analyzes the spatial relationship between different data such as vehicle routes, trip pickup and drop off points, bus stops, streets and landmarks
Internet Website	Fixed-Route & Demand-Responsive	No acronym	Allows personal computer users to easily exchange or display transit service information such as trip requests and route schedules and maps
Maintenance Software	Fixed-Route & Demand-Responsive	No acronym	Electronically processes, stores, tracks, and reports detailed vehicle maintenance and repair data, including parts and supplies inventory
Mayday System	Fixed-Route & Demand-Responsive	No acronym	Allows vehicle operator to trip an inconspicuous on-board switch to alert base station of an accident, crime, medical or other emergency
Mobile Data Terminal	Fixed-Route & Demand-Responsive	MDT	Serves as information link between control center and driver to relay relevant information, such as dispatch, trip, route, and rider data
Palmtop Electronic Manifest Device	Demand-Responsive	No acronym	Electronically stores and updates the vehicle schedule, i.e., manifest, for drivers, and provides capabilities similar to MDTs
Personnel Software	Fixed-Route & Demand-Responsive	No acronym	Electronically processes, stores, tracks, and reports detailed payroll, benefits, hours worked and personnel actions information
Pre-Trip Traveler Information	Fixed-Route	No acronym	Provides travel information to potential users at home, work, malls, public building, or tourist attractions prior to making their trip.
Stop Annunciators	Fixed-Route	No acronym	Provides audible and visible announcements of next stop, stop requested, etc.; can be applied on- and off-vehicle
Telephone Systems	Fixed-Route & Demand-Responsive	No acronym	Interactively route telephone calls, store messages (voice mail), notify recipients concerning new messages, or provide integrated voice response capabilities to provide information to callers on system schedules, fares and current service status.

Figure 4 (5.4 in the report) presents a sample table from the recommended taxonomy that presents solutions to meet one need. The body of the full report shows a table for each need. Each row of the tables represents a different APTS technology or technology category that can be applied to meet one or more aspects of a particular need. Across each row, an indication is provided as to whether or not the particular technology is deemed to be appropriate for a transit system fleet size – small, medium, or large.

The column labeled "Application" provides an indication of the applicability of the technology to particular aspects of the need in question. It also provides guidance on how the various system characteristics other than fleet size affect the usefulness or appropriateness of a particular technology.

Finally, within each need, the technologies are divided into two broad categories – basic and advanced technologies. The basic technologies tend to be those that have the potential to help solve problems for even the smallest or least complex of rural and small urban transit systems. The advanced technologies tend to be applicable to medium and large rural systems or systems with a high degree of complexity.

To apply these tables to determine available APTS options to address various needs, a transit manager should first identify the particular need in question and then refer to the appropriate table. Then the transit manager should refer to the applicable system size based on the number of vehicles operated. In determining system size, both current and projected future size, in the case of a system anticipating growth, should be considered. Next, the particular technology and its specific applicability to the need should be considered. This is where transit system characteristics other than size are factored into the evaluation. Where appropriate, the taxonomy indicates whether or not these other characteristics impact the applicability of the technology in question to the need being considered. For some needs, a given technology may only be appropriate for demand-responsive systems or only for demand-responsive systems carrying more than a given number of daily passengers, etc.

Within the taxonomy, applicable APTS technologies or system improvements have been related to specific needs and specific system characteristics based on the project team's understanding of which type of technology(ies) applies to or meets each need. These determinations are based on the interviews, site visits, and case studies conducted as part of this study effort and should be considered as general first-step guidance.

Figure 4: Technology Solutions by User Need				
Need #1: More Accurate, Easier Reporting and Record Keeping				
Basic Technologies	**Small System (<10 vehicles)**	**Medium System (10-30 vehicles)**	**Large System (>30 vehicles)**	**Application**
Customized Spreadsheet & Databases	☑			Easier collection, organization and reporting of any data; especially for small, fixed-route or demand-responsive systems that want low-cost or low-technical alternative to manual tracking and reporting. User must develop database and application.
Accounting Software	☑	☑	☑	Easier collection, organization and reporting of financial data; especially for systems without services of city or county government finance department. Database and application system already developed.
Personnel Software	☑	☑	☑	Easier collection, organization and reporting of wage, hour and other personnel data; especially for systems without services of city or county government human resources personnel department. Database and application system already developed.
Fare Media: Bar Code	☑	☑	☑	Automatically identifies passengers and funding agency for billing purposes.
Palmtop Electronic Manifest Device	☑	☑		Assists in collecting, merging and storing vehicle, passenger and trip data, especially for small systems not needing real time communication features of MDTs.
Advanced Technologies				
Geographic Information Systems		☑	☑	Automatically displays and analyzes location information for routing/service management; most useful for systems with more than 100 DRT trips/day, or with both fixed-route and paratransit, or with several human service agency clients.
Demand-Responsive Transit Software –Computer-Assisted		☑	☑	Assists reservation, dispatching and routing, and automates billing; especially for systems with more than 100 DRT trips/day or serving several human service agencies.
Demand-Responsive Transit Software –Automated		☑	☑	Assists reservations, automatically dispatches and routes using MDTs, GIS and AVL, and automates billing; most useful for systems with more than 300 DRT trips/day.
Fare Media: Smart Card & Magnetic Stripe Card		☑	☑	Automatically identifies passenger, and processes and stores trip data; most useful for systems with more than 200 DRT trips/day or serving several human service agencies.
Mobile Data Terminals			☑	Automatically collects, merges and stores vehicle, passenger and trip data; especially for systems with more than 300 DRT trips/day and needing automated, real time dispatching capability.

Measures of Effectiveness

A next step is to predict the potential benefits (qualitative and quantifiable) of the selected technologies prior to proceeding with implementation.

It is important to note that such an evaluation should occur prior to procurement and selection as part of an effective planning process so that costs and benefits can be anticipated. This tool should then be used post-implementation to assess how the technology system met projected benefits and costs. This post-implementation evaluation provides the transit manager with data that can be useful in fine tuning the system and examining personnel usage in order to reach desired efficiencies.

Figure 5 (Figure 6.3 in the report) is an outline of data to be gathered to assess improvement in reporting and record keeping activities following implementation of APTS technology. An assessment should be conducted for each key need to be addressed by implementation of APTS technology.

Figure 5: Evaluation Tool

Indicator	Current Conditions Time Period:	Projected Improvement	Projected Cost Savings (if quantifiable)	Post- Implementation Conditions (6 months after complete installation) Time Period:
1. More accurate, easier reporting and record keeping				
Staff time required for record keeping				
Staff time required for generating reports				
Staff time required for maintaining databases and reconciling errors				
Staff/management satisfaction with reporting capabilities				

Financing Strategies

Rural transit systems must often seek new and innovative ways to finance technology applications for two important reasons. First, funding for technologies commonly is from the same sources as operations and capital funding, and therefore must compete with the ongoing service, vehicle, and other capital needs of a transit system. Second, many transit boards and managers perceive technology needs as secondary to these operations and capital funding needs.

Rural transit systems must be innovative in the way they finance projects, and in many cases, may have to assemble funding from several different sources to purchase, operate, and maintain a new technology system. As one would expect, federal and state transit funds are used extensively, but there are also many alternative non-traditional funding sources. One of the most successful alternative funding strategies is to develop a technology system that benefits related human service agencies, highway maintenance and operations, and businesses in order to share the cost with these other interests. In fact, these other interests often have funding sources, such as block grants and CMAQ highway funding that can be used for transit purposes. Transit managers also use strategies to reduce the overall system cost or implement a larger project in phases over several years in order to deal with limited or inadequate funding situations.

Conclusions

The use of advanced technologies in rural and small urban transit systems is still not very common. Although transit specific technology systems have evolved over the past 10 years, most rural systems that have implemented any advanced technology are at the very basic level of deployment, usually DRT software.

The three major issues associated with advanced technologies in rural areas are:

- Costs;
- Installation/integration; and
- Properly matching technology with operational needs.

One reason for the limited installations in rural areas can be attributed to the high purchase and installation costs that can drain the limited financial resources of rural systems. Most of the transit operations that participated in our study would not have been able to install the advanced technology systems without capital or special technology funding grants.

Although most transit systems used traditional funding sources to finance their technology purchases, such as FTA Section 5311 grant funding, some were also aggressive and creative in tapping other valuable sources. Several received special FTA ITS demonstration funds. If a transit manager can realistically demonstrate to the contracting agency the short-term and long-tern benefits of technology to the agency and to agency clients (passengers), more may consider contributing to the costs. Another alternative to reduce capital costs is creative partnering, i.e., joint procurements with neighboring transit agencies.

For smaller transit systems, with no plans for significant service expansion, there are limited benefits for the cost invested in advanced technologies.

Installing a technology within a reasonable timeframe still appears to be a huge hurdle. Problems can occur on the operations side or on the vendor side. In some of the case study sites, the delays were experienced in the procurement process. Integration issues relating to software and hardware components developed by different manufacturers were difficult to resolve even in cases when a single system integrator was responsible for overseeing the complete technology system. Some of the case study sites learned that their mobile communication system (i.e., among vehicles and dispatching center) was not capable or was inadequate in transmitting both digital and analog (i.e., voice) communications. It often took longer for the sites to clean data and obtain missing customer data than anticipated. Many of the operators were frustrated that they were not readily able to produce desired reports from DRT software, especially for customer billing purposes.

Other key concerns relate to the lack of an open architecture of a particular product and the interconnectivity among the various communications systems.

A systems integrator, whether one of the product vendors or a technical consultant not affiliated with a product, is helpful

Even if capital funding is readily available, it is still important to define operational needs and then the appropriate technology to meet those needs. If the functionality of a system installed dramatically exceeds operational needs, a manager may realize after that fact that it is too labor-intensive to use and too costly to operate. As a result, the taxonomy emphasizes the relationship between system need and the use of advanced technologies. Rural and small urban transit systems are small compared to the transit systems for which some of these technologies were designed, and therefore, the technologies may present less attraction for them.

Many of the sites interviewed recognized the need to evaluate internal polices and procedures when installing technologies. This is an opportunity to update policies and streamline procedures to get the maximum benefits out of the technology and staff resulting in greater efficiencies and enhanced customer service.

Advanced technologies are not yet common in rural transit and have not reached the easy purchase and installation state of "plug-n-play." On the same hand, the state of the art is no longer in the pioneer stage when advanced transit technology in rural systems was a high-risk venture with little chance for reasonable payback.

Additional insights from this study concern actions that a transit manager should take to help insure success in installing and using APTS technology:

- Clearly define needs;
- Match the technology choice (to include low-tech and high-tech solutions) to fit operational needs;
- Conduct performance evaluations;
- Obtain support from a systems integrator;
- Identify a strong in-house project manager;
- Build the skill level of staff;
- Create the efficiencies and communication systems that enhance service to the customer.

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1.0 INTRODUCTION

1.1 Background

Intelligent Transportation Systems (ITS) encompass a range of advanced technologies that are applied to surface transportation needs including transit and highway needs. The concept of ITS was introduced in the 1960s when urban areas attempted to deal with increasing traffic congestion.

Two federally supported agencies that work closely together are responsible for oversight of ITS activities in the United States. In 1991, Congress established a public-private organization called the Intelligent Transportation Society of America (ITS America) to coordinate the development and deployment of ITS in the United States among state and local government, and transportation related consumers, industry, owners, operators, and suppliers.

The U.S. Department of Transportation (USDOT) established the Joint Program Office (JPO) in 1994 to manage the USDOT ITS program. JPO objectives include showcasing the benefits of ITS, creating funding incentives to integrate ITS projects, creating technical standards, and advancing research and professional knowledge in ITS.

The ITS program is divided into six major categories:

<u>Advanced Rural Transportation Systems</u> (ARTS) – technologies that address the unique transportation safety and mobility problems of rural communities including rural transit, highway, and other transportation issues. Examples include: demand responsive transit (DRT) software in transit systems and mobile communication systems for emergency response and highway maintenance services.

<u>Advanced Traveler Information Systems</u> (ATIS) – technologies that provide information to travelers that assist them in making decisions on their transportation choices. Examples include real-time transit vehicle location systems accessed through the Internet, dynamic messaging signs on highways to direct traffic to less congested roadways, and dynamic messaging signs at transit terminals to provide up-to-the-minute vehicle schedules.

<u>Advanced Transportation Management Systems</u> (ATMS) – technologies that increase the efficiency and capacity of existing highways. Examples include adaptive signal control systems that adjust signal timing based on traffic demands, and sensory/communication networks that relay real-time information on traffic conditions to highway control centers.

<u>Advanced Vehicle Control Systems</u> (AVCS) – technologies that allow the automated control of vehicles including automobiles, buses, and trucks.

<u>Commercial Vehicle Operations</u> (CVO***)*** – technologies that improve commercial vehicle operations such as vehicle routing and driver navigating systems.

Advanced Public Transportation Systems (APTS) – technologies used to improve the efficiency and effectiveness of public transportation operations, vehicle maintenance, and administration. These technologies include a wide range of computer databases, software, and hardware, as well as vehicle devices such as mobile data terminals (MDTs) and global positioning satellites (GPS) sensors, and automatic vehicle location (AVL) systems.

The focus of our study is APTS, the application of technologies to public transportation. More specifically, the study focuses on APTS applications implemented at small urban and rural transit operations, including both advanced and basic technologies. Advanced technologies include those that are more complex such as MDTs, AVL, and smart cards (i.e., electronic fare media). These technologies tend to apply to medium and large transit systems or to transit systems with a high degree of service complexity. Basic technology, on the other hand, has the potential to help solve problems for even the smallest or least complex transit systems, and can be considered to comprise the basic building blocks upon which the more advanced technologies are installed. Examples include custom-designed database and spreadsheet applications and financial accounting and vehicle maintenance software.

ARTS is a broader category than APTS, and refers to technologies that support the rural infrastructure and road network. Some of the case studies demonstrate how transit and highway agencies are working cooperatively in building ITS infrastructures.

1.2 Problem

It is difficult to assess the level of APTS implemented at rural public transit systems. The literature provides extensive background on technology implementations in medium to large urban/suburban areas but in many cases the level of detail is insufficient to gain insight into the effectiveness and efficiencies realized through the installations. Data are also lacking on efforts in smaller rural operations including those that have installed simple, so-called low-technology solutions. The application of advanced technologies could increase capacity, and improve safety and security for small urban and rural systems, and could make the development of new service types for nontraditional customers, such as welfare to work customers, a reality.

However, transit decision-makers such as transit boards, agency directors, and transit system management need more information to make prudent decisions on advanced technology. They need to know which technologies will benefit their customers and services, how and to what extent the technologies will impact their system, and how the technology investment will pay for itself.

1.3 Objectives

The overall goal of this study is to review the state of Advanced Public Transportation Systems (APTS), and develop materials to assist transit agencies in the selection, procurement, funding, and installation of the most appropriate APTS technologies for their mission, size, needs, and service type. The objectives of this study include:

Cost/Benefit Analysis – provide a framework to assist rural and small urban transit systems in conducting a cost/benefit analysis;

Cooperative Arrangements – determine how rural and small urban public transit systems can benefit from cooperative arrangements;

State of APTS – document the findings in a final comprehensive report; and,

Decision Guide – develop a decision guide to aid in the selection, procurement, and implementation of APTS technology that are appropriate to the size and needs of the transit system.

The purpose of this final report is to:

APTS applicability – present an approach to determine APTS applicability;

APTS in Rural Systems – identify technology system implementations in rural transit systems;

Transit/Highway Integration – identify integrated highway and public transit efforts in jointly supporting technology infrastructures;

Survey of APTS Sites – summarize findings from a telephone survey of APTS sites;

Case Study Sites – present the findings from visits to six case study sites;

Taxonomy – present a process of evaluating transit technology;

Measures of Effectiveness – present measures of effectiveness to evaluate how well advanced technology solutions meet rural transit needs; and,

Financing APTS – provide information on financing technology capital costs.

The decision guide will be published as a companion document to this report. This was designed to capture the information from the final report and compile the data into an easy to navigate guidance document for transit operators.

1.4 Methodology

Several key factors directed the research methodology including the project proposal, guidance from the research review panel, and the recommendations and experience of the project team. Telephone interviews and site visits at transit operations formed the basis for much of the study findings. The project team’s experience in transit operations, planning and technology, and the review of existing related research helped the team to develop the taxonomy and performance measures and identify potential study sites. This section offers a summary of the methods used in data gathering.

Literature Review – The literature review proved to be helpful in identifying potential study sites, providing research on performance measures, and demonstrating various ways to organize a transit-related taxonomy (i.e., by transit market segment, service modes).

State of the Practice Survey – The project team referred to previous transit technology studies and the expertise of the project team to identify APTS sites. Telephone interviews were conducted with key staff at 24 transit systems to gather detailed information on technology use, funding, planning, goals, costs, and benefits. The project team presented this detailed data to the review panel and recommended, based on a set of selection criteria, the further evaluation of six transit systems through site visits.

Case Study Site Visits – Members of the project team conducted one- and two-day site visits to the six case study sites to observe the use of the technology(ies), and to gather more detailed data on the costs, benefits, and planning and implementation processes. Based on the site visits, the project team summarized findings that illustrated success factors, lessons learned, matching of needs and technology, funding and implementation strategies, and obstacles encountered. Furthermore, the draft taxonomy and measures of effectiveness were modified based on information from the site visits.

Taxonomy Development – Based on the project team's experience and relevant literature, the team initially developed a detailed taxonomy that matched the needs of various transit interests, such as management, operations staff and users, with technologies to support those needs. The taxonomy was then organized according to the fleet size, service type, and other service characteristics. The resulting taxonomy was comprised of dozens of tables resulting from the many categories of transit interests, transit needs, system size and system type. Since this was unwieldy as a practical guidance tool, the taxonomy was simplified to make it more appealing and accessible to users. The revised taxonomy allows for the transit manager to primarily examine their fleet size (current and projected) and administrative and service needs in order to assess which technologies are the most appropriate. A transit manager can then prioritize the implementation order considering first the foundational technology along with costs and performance.

Measures of Effectiveness Development – The project team developed a set of measures to evaluate the effectiveness of APTS technologies. Based on site visits, telephone interviews with technology implementation sites, and data from the literature review, the project team identified the most significant measures and related these to user needs in the taxonomy. This relationship is demonstrated in the taxonomy matrix. For example, the staff time required to perform record keeping and generate reports are two recommended measures to evaluate the extent to which a technology meets the transit system need for “more accurate, easier reporting and record keeping.”

1.5 Definitions

Both “rural” and “small urban” transit systems were the subject of this research study, and it is to be understood that the terms are used synonymously throughout the report. These systems are operated in any area of the country that is located outside of an urbanized area (an urbanized area is an incorporated area with a population of 50,000 or more). Rural areas can encompass part of a county, an entire county, or multiple counties. These areas may encompass farmlands, recreational areas, retirement communities, and very low-density population areas. Some rural areas adjoin urban/suburban areas and involve commutes to a metropolitan area. Although this research mainly addresses the demand-responsive paratransit service modes that comprise the majority of rural and small urban operations, the study results and decision guide are generally applicable to fixed-route operations as well.

The technical terms and technology systems used in this report are defined in Appendix A. Transit technologies recommended in the taxonomy are briefly described in Figure 3.3. Appendix B contains a more extensive glossary of terms. Citations from the literature review are listed in Appendix C.

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2.0 LITERATURE REVIEW

The ITRE project team reviewed the literature to gather current information related to advanced technologies, and to learn of additional technology implementations at rural transit systems. The search drew on resources in the ITRE library, North Carolina State University library, and on-line documents and publications from various transit-related sites on the World Wide Web.

The literature search proved to be helpful in developing a preliminary list of transit systems that have implemented APTS. Documents provided information on systems including Sweetwater County Transit Authority (STAR), Sweetwater, Wyoming; County of Lackawanna Transit System (COLTS), Scranton, Pennsylvania; Capital Area Rural Transit System (CARTS), Austin, Texas; Blacksburg Transit, Blackburg, Virginia; Arc Transit, Palatka, Florida; and, Cape Cod Regional Transit Authority, Dennis, Massachusetts. Several publications produced by the Federal Highway Administration and the Federal Transit Administration provided background and inventories of currently available APTS that assisted in the development of the technology categorization and survey questions for the telephone interviews.

Furthermore, the literature provided valuable information on transit markets, technology benefits, and transit system needs. The project team used this information to assist with the development of a taxonomy, performance measures, and innovative funding strategies presented in this report. Certain key documents are referenced within the report and a more complete literature list can be found in Appendix C.

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3.0 STATE OF THE PRACTICE

This chapter summarizes operational and technology-related information on all the viable rural technology implementations uncovered through our research. Data were gathered first through preliminary telephone contacts with a total of 25 rural and small urban transit operators. These interviews were brief and were intended to capture some basic operational data and an understanding of technology implementation issues.

To obtain greater insights into implementation choices and issues, 13 of the 25 sites were then included in more detailed telephone surveys using a common survey instrument. Criteria used to select these 13 sites include: representation of various service types, operations size, and geographic regions and mix of technology types implemented. The results of the preliminary and detailed telephone interviews are discussed in the next two sections.

3.1 Preliminary Telephone Interviews

The telephone interviews provided an opportunity to contact rural and small urban transit systems with the most lengthy technology implementation track records for these size operations. The study team was familiar with many of these early implementation sites through their previous research and technical assistance work. Also included in the 25 sites were systems with more recent implementations that were not as familiar to the study team.

The selected sites are representative of the different system characteristics that may impact the experience of advanced technology implementation. The sites represent small urban and rural systems, a variety of regions throughout the country, varied types of systems such as authorities and non-profit private organizations, and many particular transit services such as fixed-route, ADA complimentary service, and human service agency service. The site characteristics vary from Blacksburg Transit in Virginia, primarily a fixed-route system providing 8,000 daily trips within a relatively small 15 square mile area, to Arrowhead Transit, a human service/general pubic paratransit system delivering 1,400 daily trips to clients in a 20,000 square mile service area.

Figure 3.1 presents basic geographical, service type, service area characteristics, and daily trip information for the 25 rural APTS sites contacted. Of the 25 sites, 17 provide fixed-route service and all 25 provide some form of demand-responsive service. Two sites, the County of Lackawanna Transit System (COLTS), Scranton, Pennsylvania and the City of Napa, Napa Valley, California only operate demand-responsive service for their required complimentary service for ADA eligible passengers (not general public or human service agency clients).

The sites range from a square mile service area of 15 to 20,000, with the average square miles covered being 2,459. The populations within the service areas of the 25 sites range from 41,000 for the Sweetwater County Transit Authority in Sweetwater (STAR), Wyoming to 1,100,000 for CARTS in Austin, Texas.

Figure 3.1: Small Urban/Rural Public Transportation APTS Sites: General Information						
Transit System	**City, State**	**U.S. Region**	**Service Type [1]**	**Service Area Size (sq. mi.)**	**Service Area Population**	**Average No. Daily Trips**
Aiken County Council on Aging	Aiken, SC	SE	FR; HS/GP DR	1,073	132,900	304 FR 69 DR
Arc Transit, Inc.	Palatka, FL	SE	HS/GP DR	798	69,516	520 DR
Arrowhead Transit	Virginia, MN	MW	HS/GP DR	20,000	200,000	1,400 DR
Ben Franklin Transit	Richland, WA	NW	FR; ADA; GP DR; HS Van Pools	452	116,500	15,500 FR 1,200 DR
Berks Area Regional Transit Authority (BARTA)	Reading, PA	NE	FR; ADA; HS/GP DR	864	200,000	10,600 FR 660 DR
Blacksburg Transit	Blacksburg, VA	SE	FR; ADA; GP DR	15	45,000	6,500 FR 50 DR
Cape Cod Regional Transit Authority	Dennis, MA	NE	FR; ADA; HS DR	400	200,000	254 FR; 1,100 FR (summer); 713 DR
Capital Area Rural Transit System (CARTS)	Austin, TX	SW	FR; ADA; HS/GP DR	7,500	1,100,000	110,000 FR 1,600 DR
Citibus	Lubbock, TX	SW	FR; ADA	115	197,117	3,486 FR 250 DR
Clemson Area Transit System (CATS)	Clemson, SC	SE	FR; ADA; GP DR	25	29,000	1,570 FR 350 DR
Community Transit of Delaware County	Eddystone, PA	NE	HS/GP DR	185	550,000	1,350 DR
Cooperative Alliance for Seacoast Transportation (COAST)	Durham, NH	NE	HS/GP DR	1,065	397,484	900 DR

Figure 3.1: Small Urban/Rural Public Transportation APTS Sites: General Information (continued)

Transit System	City, State	U.S. Region	Service Type [1]	Service Area Size (sq. mi.)	Service Area Population	Average No. Daily Trips
County of Lackawanna Transit System (COLTS)	Scranton, PA	NE	FR; ADA	164	180,000	5,205 FR
Dakota Area Resources and Transportation for Seniors (DARTS)	West St. Paul, MN	MW	FR; ADA; HS DR	535	340,000	525 FR 250 DR
Delaware Transit Corporation	Dover, DE	NE	FR; ADA; GP DR	1,982	750,000	22,700 FR 1,190 DR
Flagler Senior Services	Palm Coast, FL	SE	HS/GP DR	504	39,052	350 DR
Fresno County Rural Transit Agency (FCRTA)	Fresno, CA	W	FR; ADA; GP DR	6,005	160,000	215 FR 945 DR
Kaufman Area Rural Transportation (KART)	Terrell, TX	SW	HS/GP DR	787	64,143	250 DR
Kerr Area Rural Transportation System (KARTS)	Henderson, NC	SE	HS/GP DR	2,102	159,544	550 DR
Laketran	Grand River, OH	MW	FR; ADA	232	224,000	1,350 FR 1,000 DR
Mendocino Transit Authority	Ukiah, CA	W	FR; ADA; GP DR	3,188	83,998	900 FR 393 DR
Napa Valley Transit	Napa Valley, CA	W	FR; ADA	300	114,000	3,500 FR
Pierce Transit	Tacoma, WA	W	FR; ADA	450	623,000	35,730 FR 1,330 DR

Figure 3.1: Small Urban/Rural Public Transportation APTS Sites General Information (continued)

Transit System	City, State	U.S. Region	Service Type [1]	Service Area Size (sq. mi.)	Service Area Population	Average No. Daily Trips
Sweetwater County Transit Authority (STAR)	Sweetwater County/WY	NW	HS/GP DR	10,400	41,000	346 DR
Winston-Salem Transit Authority (WSTA)	Winston-Salem/NC	SE	FR; ADA; HS DR	400	320,000	10,000 FR 350 DR

Note: 1) Service Type: **FR** = fixed-route **DR** = dial-a-ride, demand-responsive **GP** = General Public
HS = Human Service **ADA** = ADA Complementary paratransit service

A breakdown of site locations by region is as follows:

Northeast: 6
Southeast: 7
Midwest: 3
Southwest: 3
West: 4
Northwest: 2

Over half of these implementations are within the northeast and southeast regions of the United States.

The number of daily average trips for demand-responsive service ranges from 69 for the Aiken County Council on Aging in Aiken, South Carolina to 1,600 for CARTS in Austin, Texas. The number of daily average trips for fixed-route service ranges from 215 at the Fresno County Rural Transit Agency, Fresno, California to 110,000 at CARTS.

Figure 3.2 provides data on the technology choices and implementation status for the 25 sites. DRT software, installed at 17 sites, appears to be the most common technology implemented at transit systems that provide some level of demand-responsive service (24 sites). Four of these 17 sites use computer-assisted DRT software and 13 sites use a more high-end, GIS-based automated software. Of the remaining seven sites providing demand-responsive service, two are using bar-code technology along with a simple computer-assisted DRT software to capture client data (Aiken County Council on Aging and the Kaufman Area Rural Transportation System, Terrell, Texas), one is planning to implement automated DRT software, one abandoned implementation of their DRT software, and the plans of the remaining three sites are undetermined.

Figure 3.2: Small Urban/Rural APTS Sites: Implementation Status

Transit System	Technologies Implemented	Status	Explanation (new direction/ future plans)
Aiken County Council on Aging	• AIM software (Saber Corp.) – 1997 • Bar code scanners and odometers – 1997	Operational	Bar code scanners and odometers are installed on 15 vehicles. Automatically collect trip data from vehicles. Significantly reduced personnel data entry time. GIS to be developed and used for planning.
Arc Transit, Inc.	• Automated DRT (custom) – 1997 • Magnetic Stripe Fare Cards (test on 13 vehicles) – 1997 • AVL (test on 13 vehicles) – 1997	Changed direction and behind schedule	Planned expansion of fare cards and AVL to all vehicles by 1999 was delayed. Obtained funding for AVL. Arc is working with a neighboring county in a coordinated ITS cross-county system implementation.
Arrowhead Transit	• AVL and MDTs (American Mobile Satellite) – 1997 • Automated DRT software – 1997	Project terminated	Transit portion of project terminated. Vehicle/base station communication failed to meet accuracy and speed criteria.
Ben Franklin Transit	• DRT (FleetNet) fixed-route) – 1989 • Automated DRT software (PASS; paratransit) – 1995 • MDTs (Mentor) - 1999	Operational	FleetNet provides adequate scheduling despite being 10 years old. PASS has mitigated loss in efficiency with ridership changes from group to single trips.
BARTA	• Automated DRT software (MIDAS) – 1997	Operational	System has realized administrative benefits, but disappointed that software scheduling suggestions are frequently not helpful.
Blacksburg Transit	• Automated DRT software (IntelliTrans) - 1995	Changed direction	Planned AVL, variable message signs and dedicated cable channel. AVL server malfunctioning and no plans for repair. Technical difficulties threaten all components except DRT and variable message signs.
Cape Cod Regional Transit Authority	• Computer-assisted DRT software (developed in-house) – 1990 • AVL – 1999 • MDT (Mentor) – 1999 • Internet-based customer information system –1999	Behind schedule	Customized AVL test system failed. Re-bid and installed new AVL/MDT system. Terminated DRT software contract, staying with in-house version with planned upgrade. Investigating Smart Card system. Enhancing real time vehicle location system via Internet. Installing digital radio system covering entire service area.
CARTS	• Automated DRT software (PASS) – 1995 • Digital radio system covering entire service area – 1998	Operational	Able to manage more vehicles, and reduced number of dispatchers and dispatch centers. Efficiency, cost, and service objectives accomplished. MDT installation planned.

Figure 3.2: Small Urban and Rural APTS Sites: Implementation Status (continued)

Transit System	Technologies Implemented	Status	Explanation (new direction/ future plans)
Citibus	• Electronic fareboxes (GFI) – 1996 • Automated DRT software (MIDAS) - 1999	Operational	System satisfied with fareboxes.
CATS	• GPS (Quest Track by Quest Systems) - 1998	Operational	Limited benefits, but planning to integrate with other technologies in the future.
Community Transit of Delaware County	• Computer-assisted DRT Software (Rides Unlimited) - 1996 • Automated Customer ID Program - 1998 • Wireless Data Communications System (Bell Atlantic "Air Bridge") - 1998 • MDT (Telxon) - 1999 • Web TV Reservation system – 1999	Operational, except MDTs being installed	Very satisfied with DRT software in tracking both trip times and mileage. Further in-house customization to integrate DRT and RIMS software, and provide support to other Pennsylvania transit systems using product. Web TV demonstration program developed.
COAST	• Implementation Underway	Changed direction	Planned installation of automated DRT software and AVL. Key funding contract agency elected not to participate resulting in need to modify service plan, delaying implementation.
COLTS	• AVL (Auto-Trac) • MDTs (GMSI) • Smart Cards • Voice Annunciator (Digital Recorder)	No change	No new technology implementation planned.
DARTS	• Automated DRT software (PASS) – 1998	Operational	DRT software has not produced major improvements. Schedule recommendations are frequently overridden manually. Anticipate improvements following integration with MDT/AVL system (Mentor) within next year.
Delaware Transit Corporation	• Fareboxes (GFI) - 1980's • Video Cameras - 1980's • Automated DRT (PASS) - 1998 DR, 1999 FR	Operational	Works well, but had to correct many bugs in FR software. Provides good system analysis data. By end of 2000, new GFI fareboxes and infrared APCs, and planned upgrade to Motorola radio system with features similar to AVL and MDTs.
Flagler Senior Services	• Automated DRT (RouteLogic) – 1998 • AVL (Hyperdyne) - 1999	Operational	Some delay when key official from partner agency resigned.
FCRTA	• AVL Web-based vehicle tracking – 2000	Planned installation	Researching low-cost AT&T AVL system that utilizes cellular phones, satellites, and Internet to track vehicles.

Figure 3.2: Small Urban and Rural APTS Sites: Implementation Status (continued)			
Transit System	**Technologies Implemented**	**Status**	**Explanation (new direction/ future plans)**
KARTS	• Computer-assisted DRT software (MiniPASS) - 1996	Operational	DRT software has scheduling limitations, thus, plan installation of automated DRT software (ParaMatch) in 2000.
Laketran	• Automated DRT software (PASS) – 1993	Operational	PASS very efficient. Currently conducting procurement for MDT/AVL system (GMSI).
Mendocino Transit Authority	• Automated DRT software (PASS)	Operational	Functioning properly
Napa Valley Transit	• AVL (3M Infosystems) - 1995 • Signal Prioritization (3M Infosystems) - 1995 • Automatic Stop Annunciator (Digital Recorder) - 1997	Operational	All technology components have proven effective for scheduling efficiency and timeliness. Investigating installation of on-board video cameras.
Pierce Transit	• Fareboxes (GIF Cents-a-Bill) - 1990 • MDT (Mentor) for DR service – 1997 • GPS (Mentor) for DR service - 1997	Operational	Reevaluation of communications, and investigating MDTs, AVL, AVI (signal prioritization) on fixed-route buses.
STAR	• Computer-assisted DRT software (Rides Unlimited) - 1993	Behind schedule	Installed MDTs that use bar code readers and automated DRT software. Planned AVL and Smart Cards.
WSTA	• Automated DRT software (PASS) – 1995 • AVL - test on 3 vehicles - 1995 • MDTs (Mentor) – test on 3 vehicles - 1995 • Smart Cards - test on 3 vehicles – 1995	Behind schedule	DRT software upgraded to NT version. MDT, AVL, and Smart Card systems delayed.

The technology reported in use second most frequently was mobile data terminals (MDTs), at seven sites. Five of the seven sites report fully implementing MDTs on either their ADA complimentary service or other demand-responsive services. One site is in the testing phase (the Winston-Salem Transit Authority (WSTA), Winston-Salem, North Carolina) and another site abandoned use of their MDTs, since the integration between the MDTs and DRT software was not successful (Arrowhead Transit, Virginia, Minnesota).

Though 14 sites reported investigating the use of automated vehicle location (AVL) GPS-based technology, only six sites have implemented AVL (Cape Cod Regional Transit Authority, Dennis, Massachusetts; Clemson Area Transit, Clemson, South Carolina; COLTS; Flagler Senior Services, Palm Coast, Florida; City of Napa; and Pierce Transit, Tacoma, Washington). Three postponed implementation due to integration and/or funding issues (Arc Transit, Palatka, Florida; Blacksburg Transit, Blacksburg, Virginia; and WSTA). One site, Arrowhead Transit, did not proceed with the AVL due to systems integration issues. The remaining four sites have expressed an interest in procuring an AVL system but are just in the early planning stages (COAST; DARTS; Fresno County Rural Transit Agency; and STAR).

Five sites reported testing some form of electronic payment system. Two of these sites (Citibus, Lubbock, Texas and the Delaware Transit Corporation, Dover, Delaware) have installed electronic fare boxes in their fixed-route buses. The Delaware Transit Corporation has a long track record with electronic fare collection having installed their fareboxes in the early 1980s. Two sites have tested electronic fare card media in their demand-responsive service (WSTA and Arc Transit). One site reports having implemented Smart cards (COLTS).

Approaches for selecting and procuring technology systems varied among the sites. Some of these transit sites elected to install only one specific technology, while other sites procured and installed several technology components at one time (i.e., DRT software and MDTs). One site, Kerr Area Rural Transportation System (KARTS), was one of ten sites in North Carolina involved in a statewide DRT software procurement and installation project. Flagler Senior Services and Arc Transit were involved in an inter-county test of AVL.

The information gathered through these initial screening interviews was useful in updating researchers on what technology choices were being made in rural and small urban transit systems and how effectively these technology systems were being implemented. Thirteen of these sites were selected for more in-depth interviews. The basis for their selection included: type of technology(ies) installed and level of implementation, level of transferability to other transit systems, and interest in participating in-depth interviews. The team was also careful to ensure that the candidates represented a range of transit system types and technologies.

3.2 Summary of Comprehensive Telephone Interviews

The in-depth interviews at 13 sites obtained greater insights into operational problems that could be addressed by technology, technology choices, and implementation processes. The data obtained from these interviews helped to further shape the draft taxonomy and to define those sites to be included in on-site interviews. The sites interviewed were:

- Aiken Area Council on Aging, Aiken, South Carolina
- Arrowhead Transit, Virginia, Minnesota
- Ben Franklin Transit, Richland, Washington
- Berks Area Regional Transit Authority, Reading, Pennsylvania
- Blacksburg Transit System, Blacksburg, Virginia
- Cape Cod Regional Transit Authority, Dennis, Massachusetts
- Capital Area Rural Transit System, Austin, Texas
- Community Transit of Delaware County, Eddystone, Pennsylvania
- Flagler Senior Services, Palm Coast, Florida
- Fresno County Rural Transit Agency, Fresno, California
- Kaufman Area Rural Transportation, Terrell, Texas
- Kerr Area Rural Transit System, Henderson, North Carolina

- Sweetwater County Transit Authority, Sweetwater, Wyoming

The comprehensive interviews gathered more detailed data on each transit system and the technology implementation process, including:

- Service area, service parameters, workforce and vehicle fleet;
- Technology system description, cost, selection and procurement process;
- Goals for technology implementation and leadership;
- Implementation plan, problems, successes and lessons learned; and
- Technology benefits and barriers.

The interviewees were forthcoming with the requested information and provided their unique insights into the procurement and implementation process since. Detailed data, such as the statistics and measures of effectiveness for before and after the technology implementation was generally not available. The project team did not consider the absence of these detailed numbers to be an impediment for selecting case site studies—the interviewees were able to identify a more general indicator of technology benefits that was useful for case study selection. The results of the telephone interviews follow. Refer to Figures 3.1 and 3.2 for basic operational data and technology implemented.

<u>Aiken Area Council on Aging</u>
<u>Aiken, South Carolina</u>

The Aiken Area Council on Aging is a non-profit council on aging that provides demand-responsive service (Sections 5310, 5311 funding recipient) and is the fixed-route service contract provider for the county. It is unique for a Council on Aging to be the provider of both service types. The system transported an average of 304 passengers daily on the fixed-route service, and an average of 69 passengers daily on the demand-responsive service. The great majority of trips originate in Aiken County but there are some out-of-county and out-of-state non-emergency medical trips provided.

The Council on Aging wanted information management software that could be used throughout the entire agency. They needed a way of capturing and managing data and a flexible report writer. They purchased the AIM Management Information System software (Saber Corporation) and hardware for a total cost of $27,000. This included bar code scanners and electronic odometers for 15 vehicles. The database management software and training was also included in the price. AIM was selected because the transit system did not just want transportation-specific software. Another rationale for selection of the vendor was that individuals who had previously worked in the human service field wrote the software program.

The system includes fifteen computers that are networked throughout the agency. Transportation staff exclusively utilize two of the 15 computers, and three other computers are occasionally used by other staff members to support transportation functions. ArcView is installed and used minimally for planning purposes, but the system plans to expand its use of GIS by integrating transportation and demographic data to develop better transportation and case management services.

The system installation began on the demand-responsive vehicles in January of 1997. There are plans to incorporate the technology with the fixed-route service. The agency upgraded the software in June 1999. Funding was 90% state funds with the agency contributing a 10% match. The bar code reader system has enabled the Council on Aging to significantly reduce the staff hours needed to collect and reconcile trip data for billing purposes, and provide service and location data needed to analyze client case management strategies.

Arrowhead Transit/Minnesota Department of Transportation
Virginia, Minnesota

The Arrowhead Transit service area is approximately 20,000 square miles, which is equal to about one-half the size of the State of Ohio, and covers eight counties in northeastern Minnesota. The service area is largely rural and very sparsely populated, and includes the City of Duluth and several small cities. Arrowhead Transit provides 1,400 demand-responsive trips per day.

Radio communication has been a problem due to the large service area and its geographic characteristics. The central dispatch office frequently is unable to communicate with vehicles in some locations; therefore, cell phones are frequently used as a backup to the radio system. In addition, multiple operating bases and two dispatch centers are required to serve this large service area. Vehicles operate out of five operating bases and some drivers take their vehicles home with them at night to avoid deadhead mileage (i.e., miles driven to start and end service routes).

The multiple dispatch centers plus the lack of consistent radio communication creates inefficiencies in both the operation of the system and in its administration. The communications problems also pose safety concerns particularly in the winter months and in the more remote areas of the region.

Arrowhead Transit, in concert with the Minnesota Department of Transportation (MNDOT), implemented a project that included a computer assisted dispatch system, a GPS-based AVL system, mobile data terminals (MDTs), and a communications backbone required to handle vehicle/base station data transfer. Part of the project involved equipping highway maintenance and state police vehicles with the AVL system and establishing a joint dispatch center (that included the transit system, state highway maintenance and state police), thereby allowing the transit system vehicles to serve as additional "eyes and ears" to monitor traffic, weather, and highway conditions.

The project failed during the acceptance testing phase, and subsequently the transit portion of the effort was terminated. Principal reasons for the failure related to the communications system, and the software controlling the vehicle/base station communication. The satellite communication system usually required two to three minutes to transfer information between the base station and vehicles, and in some cases delays of up to seven minutes were experienced. The software also often directed information to the wrong vehicles.

Nonetheless, the joint dispatch system continues in operation and has been a success. The highway maintenance and state police agencies continue using the AVL functions. The Minnesota DOT continues to work towards the establishment of additional joint dispatch centers throughout the state, and has determined that the joint development and procurement methods used in the project can serve as a useful model to other regions.

Ben Franklin Transit
Richland, WA

Ben Franklin Transit (BFT) is a large, multi-service transit system. Service modes include urban fixed-route transit, urban and rural demand-responsive paratransit, and vanpools. The transit system serves ADA and human service passengers, commuters and Head Start children. The BFT Authority owns 61 full size buses, 117 lift-equipped vans and a variety of service vehicles. The fixed-route vehicles carry 13,000 passengers daily, and the paratransit vehicles carry about 1,500 passengers daily. The high growth, self-contained service area covers 452 square miles.

BFT believes the character of passenger trips is changing. ADA has forced more attention on single passenger rides and away from group trips. As more single passengers, and hence fewer group trips are served, system efficiency has declined. This change has had an especially big impact on BFT because only one-half of their fixed-route fleet is ADA accessible.

BFT has installed several transit technologies, of which some have been in operation for over a decade. An aging FleetNet routing-scheduling program supports BFT fixed-route services. While FleetNet is 10 years old, it adequately schedules fixed-routes and does not need to be compatible with paratransit services. The Trapeze PASS scheduling and dispatching computer program supports BFT paratransit services. BFT first implemented PASS in January 1995 and upgraded to a more recent PASS version in January 1999. This software is used to schedule both 24-hour advance and real-time trip requests. During daily operations when passengers cancel trips, PASS updates the entire schedule, and transmits the changes to drivers via Mentor mobile data terminals. The recent PASS upgrade cost $60,000 and the Mentor MDTs cost $80,000 for 40 vehicles.

Use of the PASS software has benefited operations. Although quantitative improvements in system productivity have not been specifically identified, BFT management believes PASS has mitigated the loss in system efficiency. For example, although costs are continuing to increase, the use of PASS and MDTs has slowed the rate of cost increases.

Berks Area Regional Transit Authority (BARTA)
Reading, Pennsylvania

The Berks Area Regional Transit Authority (BARTA) operates fixed-route and demand-responsive services for Reading, Pennsylvania, a city of approximately 200,000 population, and provides demand-responsive services for Berks County, a fairly large rural county of 864 square miles. The demand-responsive service serves ADA and general public passengers, and clients from five human agencies.

The BARTA fleet is comprised of 92 vehicles, including 46 lift-equipped buses, 11 regular buses and 32 lift-equipped vans. BARTA provides an average of 10,600 daily fixed-route trips and 660 daily demand-responsive trips, including 210 human service agency and 450 general public demand-responsive trips.

BARTA needed to improve the overall service quality and operations efficiency through better scheduling and vehicle efficiency. More specifically, the transit system needed to find a more efficient method to gather trip data and generate accurate billing and service reports for the human service and state agencies that provided funding for the transit services.

First, BARTA installed a quality information system infrastructure. They procured and installed new computers, a LAN, and software that included office automation packages and specialized systems such as accounting, payroll and maintenance software systems. This installation brought their information system up-to-date and made it capable of managing the large amount of data that the subsequent scheduling software would generate. Management had much previous experience with computer conversions. As a result, BARTA provided extensive computer software training to staff and was careful to operate in parallel for a while—they operated both old and new systems until the new software system proved reliable.

BARTA had used a COMSIS paratransit scheduling software since 1986, but needed a package that better met their current needs. BARTA hired their accounting consultant to develop an RFP and Multisystems won the contract with its MIDAS software. More time than expected, a total of six months, was required to install MIDAS because significant “clean up” was required to prepare and convert data for MIDAS.

BARTA has realized significant administrative benefits. They were able to eliminate two full-time employee positions that counted and reported trips. Furthermore, they now have actual trip data for different trip types, such as hours and miles per trip, to support agency billing—whereas previously, they had to rely on sampling. Operational benefits have not been as clearly evident. System managers are not certain the software has produced any increase in operational efficiency or vehicle utilization. For example, one function of MIDAS recommends trip pickup times to reservationists, but BARTA reservationists mostly find these recommendations to be of little assistance.

Blacksburg Transit System (BTS)
Blacksburg, Virginia

The Blacksburg Transit System (BTS) serves the City of Blacksburg and the Virginia Polytechnic and State University (a.k.a., Virginia Tech). Fourteen buses without ramps and 17 buses with ramps serve the five fixed-routes and one deviated route. Eight lift-equipped vans provide demand-responsive, real-time service to ADA passengers. BTS does not serve clients of human service agencies. Fixed-route service transports an average of 6,500 daily passengers. However, ridership varies greatly depending on whether Virginia Tech is in session because 95% of the system ridership is composed of Virginia Tech students, faculty, staff and workforce.

Paratransit vans carry 50 daily passengers during fall and spring and 20 during summer. BTS is a USDOT FTA demonstration site for APTS technology.

In 1995, BTS installed the demand-responsive scheduling and dispatch program ParaPro by IntelliTran. The total cost was about $25,000 including training and maintenance. BTS believed that ParaPro improved service quality and efficiency, and subsequently installed AVL technology, a kiosk information system, a cable TV information service, and GIS. The GIS/AVL server malfunctioned and currently BTS has no plans to repair the server and restart the system. Also, BTS may eliminate the cable TV channel service.

Cape Cod Regional Transit Authority (CCRTA)
Dennis, Massachusetts

Cape Cod Regional Transit Authority (CCRTA) provides fixed-route, and advance reservation transportation services serving fifteen towns throughout Cape Cod, Massachusetts. CCRTA has contracts with eleven companies to provide transportation services including: ADA, human service, and general public demand-responsive transportation; village-based tourist trolleys; and, intercity regional routes. The CCRTA now provides approximately 110 daily advance reservation trips, and 250 daily fixed-route trips each day of the week. In addition, summer shuttle services provided approximately 100,000 trips during the summer tourism season.

CCRTA wants to increase the use of public transit to help alleviate the traffic congestion and subsequent pollution in the area, especially during the summer tourist months. Also, the authority needs to provide reliable access to jobs for the year-round residents.

CCRTA has implemented the first phase of a two-phase project that consists of an integrated GPS/AVL and computer-assisted scheduling/dispatching software. Phase I of the GPS/AVL project, which was conducted from July through December 1998, consisted of equipping 20 vehicles with GPS/AVL hardware, installing the communications infrastructure, and installing a Local Area Network (LAN). While this communications system was operational, it had only one channel for communications, which prevented simultaneous voice and data transmission. The transit system has since installed data radios in all vehicles, acquired an additional radio channel, and added two communications towers to overcome this obstacle and provide communications coverage of the entire service area.

Problems were experienced integrating the AVL system with other technology components because that system used proprietary technology. CCRTA conducted another procurement, and subsequently awarded the contract to a vendor of an AVL and MDT system that uses an open architecture. CCRTA completed installation of MDTs in eighty vehicles in July 2000, and is investigating development of a regional program to use Smart cards. CCRTA believes that a regional electronic fare payment card will be an attractive feature in their service area, with its mix of urban commute and tourism trips. The authority hopes to encourage intercity transportation providers to incorporate this system into their vehicles as a means to enable seamless intermodal transfers throughout the region.

CCRTA is also implementing a custom designed computer-assisted paratransit scheduling software. This program utilizes a relational database to integrate vehicle locations with GIS software and optimization routines. The system management felt scheduling and dispatching software offered the least potential benefit and the greatest disruption to staff, so has held off implementing that component until the GPS/AVL systems are fully operational.

Capital Area Rural Transit System (CARTS)
Austin, Texas

CARTS provides an array of intermodal transportation services in Austin, Texas and the surrounding nine-county region. The complex system includes: fixed-routes; intercity commuter routes; intercity and interstate motor coach and freight service; staging for carpool, vanpool and commuter routes from its Park-n-Ride facilities; and ADA, human service (6 different agencies) and general public paratransit services. The region is characterized by high growth, and the transit authority's service area is enormous, over 7,500 square miles. The 88-vehicle paratransit fleet includes 57 buses, of which all but three are lift-equipped; 29 vans, only four of which are lift-equipped; and two station wagons. The demand-responsive service provides approximately 1,550 trips per day. CARTS is part of the *LCRA Community Link*—a sophisticated digital voice and data system covering over 30 counties in central Texas.

In 1995, CARTS installed Trapeze PASS to improve operating and scheduling efficiency, reduce the average trip cost and improve overall service quality for the paratransit system. The large service area makes vehicle scheduling critical to the overall system efficiency. In order to realize these objectives, management believed PASS would enable CARTS to centralize the scheduling and dispatching function from four sites to a single site, and would also force staff to follow set procedures in their customer relations and trip prioritization.

The implementation experience was mixed. CARTS was pleased with the vendor's training, adherence to the schedule, responsiveness and technical support. However, CARTS attempted to act as the project integrator and manager, and as a result devoted considerable staff time to vendor coordination and problem resolution meetings and to monitoring the installation and system start up. There was often confusion as to which product or vendor was responsible for a system problem.

CARTS plans to integrate MDTs (Mobile Data Terminals) in all 60 paratransit vehicles with the PASS system to further improve customer service, vehicle coordination, communications, and real-time scheduling. This integration will be coupled with a software interface that allows customers to view scheduling options and make reservations over the Internet, and that allows customers to make a single reservation using services from several providers, e.g., wheel chair service using CARTS and Greyhound coach services. This project is estimated to cost $225,000. CARTS is able to cover approximately one-half of this cost, and therefore has applied for an ITS grant to cover the remaining one-half. The grant application is pending.

CARTS dispatchers are able to manage more vehicles using PASS and therefore CARTS has reduced the number of dispatchers needed. Furthermore, PASS and the full-coverage radio system have allowed CARTS to create a central dispatching center. The transit system believes the stated efficiency, cost and service objectives were accomplished using PASS, but cannot indicate any specific improvement in performance measures resulting from using PASS.

Community Transit of Delaware County
Eddystone, Pennsylvania

Community Transit is a private, non-profit organization that provides human service and general public demand-responsive transportation throughout Delaware County, Pennsylvania. The system consolidated transportation services for approximately fifteen human service agencies when it was founded in the early 1980s. It now provides approximately 1,350 daily human service trips for clients of 24 human service agencies.

Community Transit wants to improve scheduling and dispatching efficiency, and vehicle utilization in the wake of increasing trip volumes. The system also wants to efficiently collect time, distance and other trip data that is needed for accurate cost and billing calculations.

Community Transit has implemented scheduling and dispatching software, MDTs, a wireless data communications system, and an automated passenger identification program. The scheduling and dispatching software is a highly customized system (Queue) originally based on Rides Unlimited software. Community Transit purchased a license for the source code to this software and has integrated it with Telxon MDTs. Bell Atlantic *Air Bridge* CDPD[1] technology is used to communicate between the MDTs and the base station.

The agency is in the process of installing the Queue software at four other transportation systems throughout Pennsylvania. These remote sites will be served from a server located at Community Transportation, to allow administrators easy access to customize/modify the program as needed without travel to the remote sites.

CARTS and a client human service agency developed an automated passenger identification program that was designed to provide a means of identification that did not require passengers to carry a card or other device, as this was considered to be a hardship for many elderly and disabled passengers. Instead, the system provides digital images of boarding passengers to the driver's MDT. The digital images are attached to each passenger's file, providing a quick means of tracking trip frequency and length for billing purposes.

In addition, Community Transit is involved in a demonstration program to use Web TV in passengers' homes as a means to communicate with transportation and health care providers. Participants will be able to place, cancel, or change trip reservations through their TVs. This program, sponsored by the Department of Commerce, is an effort to demonstrate the use of advanced technologies for health care.

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1 Abbreviation for ***C****ellular* ***D****igital* ***P****acket* ***D****ata*, a data transmission technology developed for use on cellular phone frequencies. CDPD transmits data in packets which permits impressive data transfer rates, up to 19.2 Kbps, and better error correction than using modems or an analog cellular channel. A user can set up a CDPD system with relatively little equipment investment.

Community Transportation is also in the early stages of developing and implementing an automated scheduling and routing system. This system will use Resources in Motion Management System (RIMMS) software from the Descartes Group to enhance the capabilities of the existing Queue software.

Flagler Senior Services
Palm Coast, Florida

Flagler Senior Services is a private, non-profit organization that operates demand-responsive transit service throughout Flagler County for human service agency and general public clients, as well as those clients who qualify under Florida's Transportation Disadvantaged program. Flagler County is a self-contained high growth area. Senior Services' 21-vehicle fleet of buses, vans and smaller vehicles provides over 200 daily trips to clients from four human service agencies and a few dozen daily trips to the general public.

The Executive Director and the Board initiated the vision to adopt technologies to reduce overall costs, make operations more efficient, ease the administrative reporting burden and improve customer service. In addition to these system improvements, Senior Services wanted to improve regional coordination and data sharing with two contiguous counties, Putnam and St. Johns, as these systems have also implemented advanced, compatible transit technologies.

From 1995 to 1997, Senior Services installed a dedicated LAN server, nine personal computers, and RouteLogic scheduling and dispatching software. Staff uses the computer network to support all business functions, and to link data among the administrative, fiscal and scheduling/dispatching functions. The objectives of the installation were to improve the general efficiency of the agency, as well as improve operational efficiency of scheduling and dispatching, and improve customer service.

Senior Services has greatly enhanced this new information system by installing a Hyperdyne AVL system using cellular telephone technology and Trimble GPS units. The AVL and GPS units communicate with the existing RouteLogic and MapInfo GIS software to provide up-to-the-minute information on route/schedule status, permit the addition of real-time demand-responsive trips, and provide quick, efficient and accurate information for client billing to agencies.

The Director and the Board have successfully used several rules throughout the deployment: use off-the-shelf projects to reduce costs; emphasize compatibility and easy staff learning curves in product selection; and, use an incremental installation approach.

The benefits have been substantial. Besides meeting all the goals of the system's vision, management believes the technology deployment was the primary reason for significant improvements in performance measures. From 1995 to 1998, the system budget decreased from $1.6 million to $1.13 million but the same level of service was provided, while the average trips per hour increased from 1.0 to 3.4.

Fresno County Rural Transit Agency (FCRTA)
Fresno, California

The Fresno County Rural Transit Agency (FCRTA) provides both fixed-route and demand-responsive transit services to its community of 160,000. The agency runs a multitude of systems over its 6,005 square mile service area, mainly providing routes from suburbs and rural areas to and from the City of Fresno. These systems primarily serve commuters along these routes but also provide ADA service via deviations in their fixed-routes. These routes carry approximately 215 daily passengers and supplement FCRTA's paratransit service, which carries nearly 945 passengers a day.

While FCRTA does not have any advanced technologies onboard their vehicles at the current time, they had planned to incorporate a Rockwell technology package used in the vehicles of Fresno Express, the urban transit system. However, that installation would cost nearly $20,000 a vehicle. FCRTA believed that this system was too expensive and exceeded its needs. The agency has been approached by AT&T and @road with an automatic vehicle location (AVL) system that utilizes cellular technology, GPS satellites, and the Internet to track vehicles. Integrating these three technologies, @road runs with two onboard hardware units, a GPS/cellular modem unit and a dispatching unit, that communicate with a service center that relays all information and dispatching with the user system via an Internet site. The system appears promising to implement because: 1) the costs were low ($250 for the hardware per vehicle and monthly service fees from $39.95 to $90 per vehicle); 2) little training and maintenance would be necessary because the system is run by @road; and 3) the system incorporated technical support and downloadable, customizable reports directly from the Internet.

Kaufman Area Rural Transportation (KART)
Terrell, Texas

The Kaufman Area Rural Transportation (KART) is a non-profit organization providing human service and general public paratransit service in rural Texas. The twelve-vehicle fleet of buses, vans and smaller vehicles provide almost 150 daily general public demand-responsive trips and fewer than 100 daily trips to five human service agencies.

In August 1997, KART installed the AIM Management Information System. This system integrates a system of bar code scanners and vehicle odometer readers with software on their three personal computers. The scanners allow drivers to collect passenger trip information without having to write anything down. Management, having seen a demonstration of the AIM system, immediately decided that it was an inexpensive option to increase the efficiency of trip data maintenance, reporting and record keeping functions. They installed the system six months after the demonstration.

The AIM system has performed very smoothly. Installation was simple—the KART dispatcher and computer consultant easily installed the system after a few days of off-site training. AIM technical support has been very responsive for maintaining the equipment and software, and providing data base support.

The AIM system has increased administrative task efficiency. KART estimated that staff data entry time decreased by 25% to 50% and reports are generated faster as a result of the new system. Furthermore, drivers are able to more easily focus on vehicle operation because the bar code scanners simplify and expedite passenger trip data collection. The increased administrative efficiency did not achieve actual labor cost reductions because the saved staff time was diverted to other functions. KART has not quantified these benefits.

KART did not realize any improvements in system performance measures, such as reduced vehicle miles or hours, based on the new system.

Kerr Area Rural Transit System (KARTS)
Henderson, North Carolina

The Kerr Area Rural Transit System (KARTS) serves human service agencies in five North Carolina counties. The service area is classified as large and sparsely populated. Its five counties together are larger than the state of Delaware yet the total population numbers less than 180,000. The KARTS transit authority owns 35 standard vans with no lifts, and 13 vans with lifts. These vehicles carry a total of about 550 passengers per day. Approximately 75 percent of passengers are provided service under subscription contracts with human service agencies, and about 50 passengers per day are general public clients. As many as 10 drivers, who average nearly 5 hours of work each day, freely donate their driving services under the auspices of associated human service agencies.

In 1996, KARTS was among the first users of Trapeze MiniPASS, a reduced functionality version of the PASS scheduling software. The total contract price including six workstations was about $35,000. NCDOT and ITRE contributed significantly to procurement and training. The six-month implementation required much extra time from the director and assistant director to collect and input client addresses and destinations, special needs, routes, vehicle, driver, and other information into MiniPASS. Transitioning from “pencil and paper” to the new computer system was very awkward. Relatively unskilled, non-technical staff had to become “computer literate”. Much customization was necessary.

The final implementation fell short of the desired area-wide automatic scheduling tool because MiniPASS cannot separate vehicles by county of origin and ownership. This capability is necessary to track county contributions. In spite of not fully scheduling, but rather “organizing” trips and resources, MiniPASS has improved service quality and efficiency according to KARTS management. There is no indication that costs have decreased.

In 2000, a large group of North Carolina transit systems conducted a group procurement to purchase automated DRT software. KARTS was a member of that group, and plans to install ParaMatch in the second wave of software installations resulting from that procurement.

Sweetwater County Transit Authority (STAR)
Sweetwater, Wyoming

The Sweetwater County Transit Authority (STAR) provides human service and general public paratransit services in an expansive, sparsely populated county, which is larger than nine of the U.S. states. STAR provides almost 340 daily trips for over a dozen human service agencies and a similar number of daily trips to general public clients. The fleet includes ten buses, four vans and one four-wheel drive automobile.

In 1989, STAR consolidated human service transportation in Sweetwater County by taking over the agencies' vehicles and transportation responsibilities. In 1990, a simple radio system, GE radios costing a total of $2,000, was installed to communicate with vehicles in the expansive service area and improve safety, vehicle coordination and utilization, and scheduling/dispatching. STAR attempted to prepare the daily vehicle schedules using Calendar Creator and Dbase but this system was ultimately inadequate.

Two years later, they replaced this system with Motorola cell phones and upgraded their computer capabilities by installing a computer-assisted dispatching software, Rides Unlimited, to complement the new communication system. The first radio installation took only about six months from concept to implementation, but this replacement system was more complex and took over a year to complete the same cycle. Driver responsiveness to the new system was a barrier in using the replacement system, as drivers took a few months to let go of their old practices.

These new technologies cost about $200,000 but provided extensive benefits. From 1990 to 1995, the cost per trip decreased from $8.36 to $4.22 and the vehicle operations cost fell from $41.66 to $26.65 per hour. Although, the consolidation of the agency transportation provided the basis for these astounding efficiency improvements, the communications network and dispatching software provided a foundation on which to execute the full consolidation and benefits.

STAR planned to install an automated DRT software and MDT system to further reduce the vehicle response time. The MDTs read bar codes and collect odometer readings for each trip. The complete upgrade is expected to cost $200,000. STAR was awarded a grant from the USDOT/FTA to fund most of the project, but they were not able to proceed because their board did not approve the local match funding. STAR still intends to move forward with technology implementation. They are working with a computer system programmer to develop a custom DRT software application in-house. After a reassessment, they plan to again pursue technology grant funding. STAR has done extensive partnering with the Utah Transportation Center and several public and private entities. These entities bring expertise and financing to the project to help overcome some of the biggest implementation barriers such as technology integration, lack of communication infrastructure and the relatively high project cost.

3.3 Summary

The project team gathered much data to be used in developing the taxonomy and selecting transit systems for case study visits. An examination of the 13 transit systems that were the subject of the comprehensive telephone interviews reveals a trend worth noting. Many of the early demonstration projects indicated that they were behind in their implementation schedule or have simply changed direction. Schedule delays, as reported by those interviewed, have been the result of a combination of problems that include issues with:

- Integration of technologies
- Scheduling/routing software upgrades
- Procurement processes
- Slow responsiveness of vendor
- Management changes
- Policy decisions

Many technology plans significantly changed because they encountered problems with technology implementation or funding, or actually expanded plans to take advantage of opportunities created by new technology options. Three of these 13 systems had no immediate plans for additional technology deployment. The implementation delays and technology plan changes of a few of these sites are discussed in greater detail in Chapter 4, which presents information on case study site visits.

The project team used the information from the comprehensive telephone interviews to select six case study sites for further examination by a site visit. The following chapter provides the criteria for selecting these six sites and the detailed findings from the site visits.

4.0 CASE STUDY RESULTS

This chapter discusses the selection of, and findings from six case studies in which APTS applications in both the operational and planning stages were examined in detail. Through these detailed case studies, the study team identified the planning, management, funding and implementation approaches, the extent of application success (measured through the benefits achieved), and the lessons that these successful applications have for other transit systems and areas.

4.1 Selection Process

The study team sought a set of case study sites that represented a broad cross-section of services, technologies, and locations. The following criteria were used to select case study candidates:

- Use of different types of APTS, either singly or in combination
- Experience with and length of use of the installed technology(ies)
- Needs and functions that the technology is supporting
- Range of demographic characteristics, including geographic location, population size and density, and transit system size
- Variety of location characteristics including high/low growth, rural/metropolitan commute, tourist area, and single county/multi-county/regional service
- Desire of transit system staff and local officials to serve as case study participants
- Existence of data to contribute to the evaluation of the site as a case study

Based on these criteria, six case study sites were selected for detailed examination.

4.2 Rationale for Case Study Selection

Preliminary information was gathered on case study sites through telephone interviews discussed in Chapter 3. This information included operational data as well as problems being addressed by the technology. Figure 4.1 is a summary table of the relevant service and demographic characteristics of these sites. Appendix F provides a detailed narrative of the results for each site.

Figure 4.1: Characteristics of Case Study Sites

System Name	Location and Region	Transit Service Area	Service Area and Population	Vehicles and Avg. Daily Trips	Technologies/ Years Implemented	Technologies Planned
Aiken County Council on Aging	Aiken, SC (Southeast)	Self-contained, low growth community, rural tourist area	1,079 sq. miles; 132,000 population	15 vehicles; 304 FR, 69 DR	• Bar Code Identification, computer-assisted DRT software – 3 years	• GIS • AVL
Arrowhead Transit	Virginia, MN (Midwest)	Large, sparsely populated rural area	20,000 sq. miles; 200,000 population	53 vehicles; 1,400 DR	• Automated DRT software, satellite communications, AVL, and MDT – (project terminated)	No current plans
Cape Cod Regional Transit Authority	Dennis, MA (Northeast)	Rural to metropolitan area commute, rural tourist area	400 sq. miles; 200,000 population	100 vehicles; 250 to 1,110 FR, 700 DR	• Computer-assisted DRT software – 10 years • GPS/AVL – 1 year (pilot test) • AVL via Internet – 1 year • GPS/AVL – < 1 year • MDTs – < 1 year • Digital radio for entire service area – current implementation	• Automated DRT software • Smart cards
Capital Area Rural Transit System (CARTS)	Austin, TX (Southwest)	High growth (small city plus nine counties); rural to urban commutes	7,500 sq. miles; 1,100,000 population	60 vehicles; 1,600 DR	• Automated DRT software – 6 years • Digital and voice radio system – 2 years	• MDTs

Figure 4.1: Characteristics of Case Study Sites (continued)						
System Name	**Location and Region**	**Transit Service Area**	**Service Area and Population**	**Vehicles and Avg. Daily Trips**	**Technologies/ Years Implemented**	**Technologies Planned**
Community Transit of Delaware County	Eddystone, PA (Northeast)	Slow/no growth, self-contained local community	185 sq. miles; 550,000 population	110 vehicles; 1,350 DR	• Computer-assisted DRT software – 4 years • MDTs (pilot test) – 2 years • CDPD wireless data communications – 2 years • Automated customer identification program (pilot test) – 1 year • Web TV reservation system (pilot test) – 1 year • DRT s/ware service provider – 1 year • MDTs, fleetwide – < 1 year	• Automated DRT software
Flagler Senior Services	Palm Coast, FL (Southeast)	Self-contained high growth area	487 sq. miles; 110,000 population	16 vehicles; 350 DR	• Automated DRT software – 2 years • AVL/GPS – < 1 year	No current plans

A brief overview of the unique qualities of each site that determined their selection as a case study follows.

Aiken County Council on Aging – The Aiken Area Council on Aging, in Aiken, South Carolina, is an example of a small non-profit agency that provides both demand-responsive and fixed-route services in a medium-sized, rural service area. The agency's use of a bar code system and computer-assisted DRT software is a low-cost technology solution. A firm that traditionally markets products for human service and senior citizen case management, not for the transit industry, developed the system.

Arrowhead Transit/Minnesota Department of Transportation – Arrowhead Transit serves an enormous, sparsely populated, rural area that is one-half the size of the state of Ohio. Their APTS installation was an attempt to integrate highway, public safety, and public transportation applications. It provides a good example of a state-local government partnership to solve regional, multi-agency problems, and the need for system testing and detailed procurement specifications.

Cape Cod Regional Transit Authority – The Cape Cod Regional Transit Authority (CCRTA) is a regional system, which provides a complex array of both fixed-route and demand-responsive services in a tourist area. This system provides a good example of the integration of a variety of technologies, transportation modes and agencies. It is also a good example of the benefits that can accrue from first installing a solid technology infrastructure, and then using innovative procurement policies, partnerships, and funding strategies.

Capital Area Rural Transit System (CARTS) – CARTS is a large, complex regional system that provides an array of fixed-route and demand-responsive services in both rural and urban areas of the southwest. The region is characterized by high growth. The transit authority's service area is very large, over 7,500 square miles. The complex system includes: fixed-routes; intercity commuter routes; intercity and interstate motor coach and freight service; staging for carpool, vanpool, and commuter routes from Park-n-Ride facilities; and, ADA, human service (6 different agencies) and general public demand-responsive transportation.

CARTS has relatively long-term experience using a computer-assisted DRT software. This level of experience with any technology is relatively rare, particularly at rural transit systems.

Community Transit of Delaware County – Community Transit of Delaware County provides paratransit service in a suburban-rural area in the northeast U.S. This system provides a good example of the effective use of highly customized off-the-shelf communications technology, and the innovative use and integration of uncommon technologies such as a ‘customer friendly’ computerized photo ID system using MDTs, and the use of WebTV. It also provides a strong case for use of clearly defined specifications in procurement documents, use of multiple product providers and the need for a dedicated technical staff person.

Flagler Senior Services/Arc Transit, Inc. – Flagler Senior Services is a nonprofit organization that provides demand-responsive transit services in a rural county in the southeastern U.S. for human services agencies, the general public, and clients of Florida’s Transportation Disadvantaged program. The service area, Flagler County, is a self-contained high growth area. Flagler Senior Services effectively cooperates with adjacent area service providers in the selection and integration of new technologies.

This system provides a good example of the use of off-the-shelf products to reduce costs, the integration of several technologies, the emphasis of compatibility and training needs in product selection, the collaboration with adjacent jurisdictions to facilitate transfers, and the benefits of using an incremental approach to installation.

4.3 Summary of Findings

The project team collected much valuable information from the case study sites during site visits and telephone interviews. There were some common themes that emerged from the sites that illustrate success factors, lessons learned, approaches to matching needs and technology, preferred order of product installation, and other characteristics of these transit technology leaders. These common themes, or findings, are presented in this section, and represent valuable information to transit mangers, staff, researchers, consultants, and grant administrators for understanding the application of technology in transit systems.

4.3.1 Reasons for Implementation

The primary reasons for implementing new technology in most case study sites began with the desire to increase efficiency (and therefore reduce costs) and improve service quality. Other reasons for technology implementation include improving public safety, taking advantage of funding and partnership opportunities, and preparing for future integration of transit services with other providers. Figure 4.2 summarizes the primary reasons that case study sites gave for implementing APTS technology.

The reasons for implementing the technologies are certainly results of conditions that exist in almost any transit system. Most transit systems seek to reduce costs, increase efficiency and improve service quality. However, outside of the relatively small number of transit operators evaluated in this study, few transit systems actually attempt to implement advanced technology systems. Why are the case study sites at the forefront in technology implementation in rural transit? There is obviously an impetus that exists in these leading systems. As the remainder of this section discusses the other study findings, it will identify the leadership, funding, partnership, and other issues that provided the impetus for systems to implement APTS.

4.3.2 Leadership and Vision

Leadership was a key variable present at each case study site. There was always a project champion, whether one person or a group of individuals, who had the vision, took the risks, made the funding and technical connections, and generally provided the impetus to make the project happen. Without these leaders, it is uncertain that the technology projects would have been conceived, much less planned and ultimately implemented.

Figure 4.2: Reasons for Implementing Technology			
System	**Efficiency**	**Service Quality**	**Other**
Aiken County Council on Aging	• Save staff time (reduce staff and driver data entry) • Generate more accurate data for billing and service analysis	• Integrate transportation and case management information to improve overall client service	No other reasons cited
Arrowhead Transit	• Reduce administrative costs by consolidating dispatch centers • Improve vehicle trip efficiency • Improve billing and record keeping	• Improve safety, especially during winter months, in remote areas where there are communications problems	• MN DOT's desire to demonstrate joint development process and dispatch centers • FTA's desire to demonstrate multi-modal transportation technology systems
Cape Cod Regional Transit Authority	System efficiency was only a minor reason for Cape Cod to implement transit technology.	• Increase consumption of public transit • Provide reliable access to jobs for year round residents (much public pressure) • Integrate various transportation modes and service areas	• Alleviate increasing traffic congestion and pollution, especially in summer months (much public pressure) • Develop strong private-public partnership that provides funding opportunities • FTA's desire to demonstrate transit technology in a tourist area
Capital Area Rural Transit System (CARTS)	• Consolidate six dispatch centers to reduce operations costs • Increase productivity • Improve reporting and record keeping	• Treat customers equally in reservations and scheduling priority • Improve radio coverage for better safety and on-time performance • Improve overall service quality	• Provide communication, software and a database structure for future technology installations
Community Transit of Delaware County	• Increase productivity through improved scheduling, more flexible real time dispatching, and better monitoring of driver performance • Increase efficiency of the reservation process between the transit system and health care providers	• Improve communication among transit service, human service agencies, and clients	• Meet identification requirements of the state Medical Assistance Program • Develop a cost-effective wireless communication system to enable further technology installations
Flagler Senior Services	• Improve productivity by reducing paperwork and efficiently collecting better data for analysis and reporting	• Integrate transit service with adjacent counties	• Reduce transit system dependency on only a few staff persons

The Cape Cod Regional Transit Authority (CCRTA) provides an excellent example of the impact leadership has on a successful project. The ITS project manager at CCRTA is a consultant who previously provided technical support for successful CCRTA projects, and is considered an ITS expert with excellent knowledge of funding sources. Furthermore, the CCRTA administrator, assistant administrator and the operations manager possess strong leadership experience. This leadership team successfully attracted FTA Section 26, CMAQ (Congestion Management and Air Quality) and state transportation funding, and formed necessary partnerships with adjacent transit authorities and private businesses. Furthermore, the broad professional experience represented by this team, including in-depth knowledge of GIS and computer technology, and transit management, administration and operations, has provided the technical background needed to integrate a complex system of new technologies, and to effectively build a partnerships among diversified agencies and interests.

At Flagler Senior Services and CARTS, it is clear that the directors of those agencies provided strong leadership from conceptual design to system installation and adjustment. However, leadership does not always originate from one individual. In the Arrowhead Transit project, the Minnesota Department of Transportation (MNDOT) took the lead in developing the funding and management plans, securing demonstration funding from the U.S. DOT, and then providing the local share of the project funding. Arrowhead Transit would not have had the opportunity to even attempt the communications changes it planned without the leadership of, and partnership with this state agency. In fact, while some technical aspects of the Arrowhead project failed, the MNDOT partnership concept was considered successful and the state is looking into other partnership projects to develop.

Vision is a key ingredient that seemed to come with quality leadership. All the case study sites are essentially implementing an ongoing technology plan that their strong leadership envisioned. They have a formal planning process that doesn't end with the implementation of a single technology system, but instead lays the groundwork for the next bold step. CARTS envisions a single dispatch center that controls over 60 vehicles in nine counties using automated DRT software, a state-of-the-art voice and digital radio system, and MDTs. Arrowhead and its partners saw a single dispatch center for rural transit, highway maintenance and state police agencies. The CCRTA seeks a fully integrated fixed-route, paratransit, intercity, taxicab and ferry transportation system using the latest transit technology, and a smart card system integrated with banks and retailers. The other sites possess equally challenging technology plans.

Project leadership is absolutely essential to success. It provides the impetus to put together the project vision, ties together the needed partnerships, attracts the funding, and manages the project through the many technical and implementation barriers. Each study site experienced funding and technical barriers of varying degrees, but quality leadership and vision kept these projects moving forward.

4.3.3 Partnerships

The case studies clearly demonstrated the value of working in partnerships with state and local agencies, transit and human service providers and private interests. The partnerships produced many valuable benefits in which the agencies:

- Split the cost of the technology systems and infrastructure;
- Increased the attractiveness of project for funding, ultimately multiplying the number of funding sources; and,
- Broadened the technical and managerial expertise and experience to bear on the project.

Figure 4.3 provides details on the many partnerships that the case study sites effectively used. The private partnership that includes the Cape Cod Regional Transit Authority (CCRTA), Greater Attleboro Taunton Regional Transit Authority (GATRA is the adjacent transit authority), and the GeoGraphics Laboratory at Bridgewater State College is a prime example of a partnership providing valuable benefits to all the parties.

First, they conducted group procurements that lowered costs and provided negotiating leverage with technology contractors. Over the long run, the transit system managers and the University researchers have brought together a superior level of respected experience and knowledge and have been able to implement a complex, integrated transit technology system. They were able to project the confidence needed to attract funding from federal, state, and local sources, and even from traditionally highway oriented sources (i.e., CCRTA received Congestion Management and Air Quality program funding).

Currently, CCRTA is working to extend this partnership to other transportation operators such as intercity bus carriers, ferry service, and taxicab companies to better coordinate connector service by integrating parts of the scheduling software and MDT system, and to private businesses such as retailers and banks to investigate the use of smart cards to purchase transit service and retail goods, and add money value to the smart card.

Community Transit of Delaware County partnered with other agencies to design and successfully integrate a variety of technology systems. The requirements of a major Community Transit client, the Medical Assistance program, drove the design and installation of a system that automatically transmits a picture of the client to the vehicle MDT to ensure client identification and subsequent eligibility. A special project with the Crozier Medical Center that was funded by the U.S. Department of Commerce, called WebTV, allows Center staff to request client trips through an electronic mail hookup, thus reducing the number of calls to the Community Transit reservation line. In both of these cases, although these requirements brought the complexities of additional system requirements, the resulting technology systems were financed with grants that were traditionally not considered by transit systems.

Perhaps, Community Transit has taken the idea of partnership to a new level. They and several other systems have formed a partnership not to purchase technology, but to actually develop and support their own technology system. Community Transit purchased the rights to an existing DRT software and subsequently customized the product to more precisely meet their needs. The system is implementing the customized software, now called Queue, at four public transportation sites in Pennsylvania, and will provide technical support to these systems for a set fee. These revenues provide funding to ensure the continued development and improvement of the software.

Figure 4.3: Partnerships

System	Partners	Activities	Benefits
Aiken County Council on Aging	Several senior citizen program providers under Council on Aging	• Procured information system that integrates transportation and case study functions	• Integrated information system and lowered administrative costs
Arrowhead Transit	MN DOT public transit, MN DOT highway maintenance, MN State Police	• MN DOT developed funding and management plans, paid local share for matching funds • Joint procurement	• Joint dispatch centers for MN DOT highway maintenance and MN State Police • Higher level of technical expertise • Model to other state agencies for joint development and procurement
Cape Cod Regional Transit Authority	Formal consortium -- CCRTA, GATRA (adjacent transit authority), Bridgewater State College, businesses (banks and retailers)	• Joint procurement • Funding search • Technology specifications developed for regional transit integration	• Expanded funding opportunities • Lowered cost in group procurements and provided negotiation leverage with technology companies • Higher level of expertise and experience • Integrated regional transit services
Capital Area Rural Transit System (CARTS)	Member of LCRA Community Link which covers 30 counties for digital voice and data systems	• Installed and maintained region-wide radio system	• Reduced cost for region-wide radio system • Reduced number of dispatch centers from 6 to 3.
Community Transit of Delaware County	Four other Pennsylvania public transit agencies; Crozier Medical Center; state Medical Assistance Program; U.S. Department of Commerce	• Demonstration project for Web TV • Demonstration project for client picture identification system • Developing DRT software for other public transit sites	• Opportunities to demonstrate innovative technologies • Integration of information systems with health care providers and higher quality service • Decreased cost to transit agencies to obtain DRT software
Flagler Senior Services	Transit operators in neighboring counties	• Joint procurement	• Lower procurement costs and better vendor technical support

In the case of Arrowhead Transit, the regional transit system partnered with the state DOT, the highway maintenance department, and state police. The state DOT provided the staffing and technical expertise to design a regional AVL system, and the influence to secure the necessary funding. Having the AVL system integrated with the highway maintenance agency helped to underwrite the system cost and enabled the project to tap funding sources traditionally reserved only for highway projects.

In some cases, a partnership was essential to the technology system infrastructure. CARTS entered into an interlocal agreement with the Lower Colorado River Authority to secure full voice and digital radio communications throughout their nine-county service area. This radio system forms the communications infrastructure that enabled CARTS to use DRT software to consolidate dispatch centers, and eventually install MDTs.

A partnership does not always have to be with another agency, but can have an intra-agency approach. The case management and transit operations functions at the Aiken County Council on Aging cooperated to meet the needs of the transit function such as the efficient performance of trip reservations, gathering vehicle trip data, and producing billing and grant reports. They purchased and integrated the AIM transit software module with their existing AIM case study management software. The integration of the case management and transit program and database modules allows client case management to include general and transit service information. Furthermore, staff is able to more easily share their computer resources.

Although partnerships provided great benefits, the need to coordinate and consolidate the interests of various agencies in a partnership presents some inherent complexities. Flagler Senior Services, Inc (FSS), acting as the lead agency, developed a partnership with two other operators to reduce project costs and facilitate service integration among the partners. FSS expended much effort to reach a consensus among partners concerning the system design and procurement. At one point, the key participant of one partner agency resigned, and as a result, FSS took six months educating that person's replacement in order to keep the agency in the partnership.

Partnerships offer the opportunity to expand the capabilities or lower the costs of a technology system, but partnerships can also complicate the overall technology system requirements. Technology system requirements tend to expand or broaden as the number of partners increases. This expansion is especially true if the partnership is composed of agencies with a wider variety of transit modes, e.g., fixed-route and human service, or with broader agency missions, e.g., transit systems and human service agencies. For example, the base technology system of Community Transit of Delaware County is composed of DRT software and MDTs. However, the Medical Assistance program, a Community Transit client program, was concerned that only eligible clients receive transportation services, and as a result, the automated picture identification system for the transit service vehicles was developed and installed.

The great benefit resulting from partnerships was a consistent theme among the case study sites. However, an effective partnership requires considerable leadership skills to consolidate the varying interests of the partners and keep the partnership focused and moving forward.

4.3.4 Planning Process

Formalized Planning Process

All the case study sites established a formalized technology planning process, and most sites had a committee involved in the planning that included members from area transit operators, human service agencies, funding agencies, highway operations and maintenance agencies, and other related entities. Even the Aiken County Council on Aging, that installed a relatively low-cost bar code reader and software system, has a long-term plan to enhance that system with GIS and perhaps AVL and smart card technology. This planning process was ongoing—it appeared to be an integral part of the site's business functions along with management, operations, administration, maintenance, etc., rather than a special, one-time project.

Phased Approach

As part of this planning process, most study sites successfully used a phased approach to select, procure, and install technology. They commonly installed one component of an overall technology strategy plan, such as DRT software or an expanded radio system, into a few test vehicles or for an isolated service component such as Title III transportation service. Once that technology component was functioning properly and proved feasible, full implementation of that component was completed while the system began planning and procurement development for the next technology component. Using a phased approach has several advantages:

- Transit staff has adequate time to learn and adapt to new technology while carrying out their other day-to-day duties
- The system can more easily isolate and fix technical problems
- Given the limited technology budgets of most transit systems, a phased implementation over several years is the only manner in which many systems can afford a complex, integrated technology system
- If a system component fails, the system will still have properly functioning components from previous installation phases

A review of Figure 4.1 illustrates the use of a phased, ongoing approach. In that table, the column titled "Technologies/Years Implemented" displays the sequence and timing of technology components for each study site. The technology components were installed in various phases over several years except in the cases of Aiken County and Arrowhead Transit. Nonetheless, the Arrowhead Transit system used shorter installation phases that included an acceptance test phase. Furthermore, all systems, with the exception of Arrowhead Transit, have near-term plans to continue adding components and capabilities to leverage the benefits of their installed system. The Cape Cod Regional Transit Authority installed customized DRT software 10 years ago, has continued to plan and install additional technologies such as digital radio channels and MDTs, and plans to upgrade their DRT software and install smart card capabilities.

The phased approach to technology implementation does have drawbacks. When the various components of a transit technology system are implemented over several years, the components that are installed first can often be out-of-date by the time full deployment is achieved. This problem can occur especially in situations where funding or technology problems have delayed installation for many months, and beyond. For example, Community Transit encountered a two-year delay installing MDTs. Although the MDT component is still expected to produce substantial benefits, this component is no longer state-of-the-art and therefore has some limitations compared to corresponding technology, such as GIS and AVL, that Community Transit plans to add to the system.

Staff Resistance

Study sites often found that there was substantial suspicion among staff concerning the use of new technology. This reaction is certainly not endemic to only the transit industry; almost every business encounters similar reactions among staff when new technology promises to bring about unknown and great changes. For example, Community Transit experienced staff resistance to MDTs, particularly on the part of drivers who were concerned about the “big brother” aspect of the technology. Even though Flagler Senior Services is an organization that the Executive Director describes as “used to change,” staff was fearful in transitioning from the established, known, manual scheduling system to automated DRT software. CARTS found staff reluctant to use the new automated DRT as it was intended.

Study sites believed it important to work with staff throughout the planning, procurement, and implementation process to reduce fear of a new technology and the consequent resistance to its use. Sites reported that they dedicated substantial time communicating and working with staff to make sure they developed a positive vision of how they would work with the new technology and the advantages the technology offered to them.

4.3.5 Implementation Process

Ongoing Product, Policy, and Procedures Development

For the case study sites, implementation of a technology product was not just a short series of one-time installation tasks—it was an ongoing project. The transit systems did not simply learn all the technology product capabilities, and in a few weeks, make all the service, policy and procedural changes to take advantage of those capabilities. The systems continually learned new product capabilities, and consequently implemented new policy and procedures to take advantage of those capabilities and the large amount of accurate data that is automatically provided by most transit technologies. For example, CCRTA installed GIS/AVL in many of its fixed-route vehicles to provide data needed to better manage on-time performance. Subsequently, the system developed the first phase of the Advanced Travel Planner (ATP) which provides a display of vehicle location to the public via the Internet, has learned to use the location data to more satisfactorily resolve customer complaints, and shares GIS and highway congestion data with area land use and highway planners. In the case of CARTS, their current use of the DRT software and MDTs is only the “tip of the iceberg.” The system plans to offer immediate service requests, allow trip reservations to be made using the Internet, and develop a new generation of more accurate operations and management reports.

Each case study site had numerous examples of the manner in which they continue to develop the use of a technology component over many months and several years. For example, Aiken County, which installed a relatively simple technology solution (i.e., on-board bar code reader and computer-assisted DRT software), plans to continue developing applications based on the large relational database that the system automatically provides, and to integrate that data with other relatively simple technologies, such as GIS, to yield great benefits.

Dedicated Manager

The study sites demonstrated the value of having a dedicated staff person to take the lead and responsibility for technology development and implementation. Community Transit of Delaware County recognized the importance of having a dedicated manager for complex technology implementation. When the DRT software and MDT installation began, no single staff person was assigned complete responsibility for the installation. The ongoing planning and technology installation suffered as staff focused on their usual transit service duties, and struggled with juggling their day-to-day duties with installation testing and training. The projects began to move swiftly forward once a dedicated manager was assigned to the technology projects. Community Transit is convinced that the system would have saved time and money had a dedicated manager been assigned to the technology installation at the project start.

Training and Staff Skills

Quality and comprehensive training is essential to a successful technology implementation. Training helped staff develop the technical skills to make them feel more competent, and subsequently overcome the typical user fears that often accompany the implementation of new technologies. Training and skill development also helped staff develop a vision of how technology could help them better complete their duties. Flagler Senior Services, Inc. worked closely with the vendor to ensure that all staff received needed training, and believed that the vendor was very responsive to their training needs. Flagler viewed quality training as the most important element to successful technology implementation. Although the system was satisfied with the training received, management believed so strongly in the great benefits of ample and quality training that they planned to concentrate even more on vendor training in their next technology system. Other study sites commonly cited training as a critical component to develop competent staff and increase staff acceptance of new technology.

Vendor Support

Quality vendor support is key to successful implementation. This support is especially critical during the first six months of implementation when transit system management and staff are learning to use the technology and adapt their operations procedures and policies to derive the greatest benefits possible from the new system. Study sites generally experienced good vendor support, which may be attributed to the careful planning and research conducted by the systems prior to selecting a vendor. Systems were generally careful to select a vendor with a good track record of support. The strong leadership among the study sites also appeared to keep pressure on the vendor to provide responsive, quality technical support. Study sites that experienced low-quality or slow vendor support reported substantial negative consequences as a result.

Implementation Schedule

Most of the study sites are behind schedule in implementing their long-term technology plans. This study takes advantage of technology plan information collected from a related transit technology study (*Small Urban and Rural Advanced Public Transportation Systems* for the Federal Transit Administration) and similar information collected during site visits to highlight some of the causes for delay, as presented in Figure 4.4.

Figure 4.4: Technology Plan Status

Transit System	Technologies Planned for 1999	Status and Cause of Delay
Aiken County	• Computer-assisted DRT software • Bar code scanners and odometers • GIS interface to database	Software and scanners are operational. Staff does not have time to develop GIS interface.
Arrowhead Transit	• Automated DRT software (Midas) installed • AVL • MDTs	Project terminated. Technical problems: MDT messaging took 2-7 minutes; and, MDT messages misdirected.
Capital Area Regional Transit System	• DRT software • Digital radio for entire service area • MDTs	Software and radio system are operational, no major delays have been experienced. MDTs are being installed.
Cape Cod Regional Transit Authority	• Automated DRT software • AVL • MDTs • Smart cards • Internet-based customer information system	MDTs and AVL in most vehicles, and basic customer information is operational. Technical and procurement problems: Phase I AVL terminated and re-bid; DRT software contract terminated because product did not meet operational requirements. DRT software to be developed in-house. Digital radio requirements demanded additional radio channel.
Community Transit of Delaware County	• Computer-assisted DRT software • MDTs • Wireless data communications system	Software and communication software fully operational, but still installing MDTs. Financial problems delayed installation for almost two years.
Flagler Senior Services	• Automated DRT software • AVL/GPS	Fully operational. Only minor delays experienced.

As evidenced from the information presented in Figure 4.4, the reasons for implementation delays relate to technical, financial, procurement and staff workload problems. Technical and procurement problems are usually related to the transit organization's lack of technical skill and experience, and appear to occur most often when an organization plans and installs its first set of technology products. For some systems, such as CARTS, hiring a consultant to carry out the procurement process may have reduced the likelihood of delays and problems. Likewise, the use of a system integrator to design and install the technology system may have reduced delays, but this method was no guarantee against major setbacks. There seemed to be no substitute for the experience and knowledge that the actual planning, procurement and installation of transit technologies provide to transit management and staff.

Some technology planning and implementation problems are related to the status of technology status within transit organizations. Technology hardware and software are among the first items to be deleted from a transit organization's budget when funding becomes tight, or constrained staff and management time must be dedicated to the relatively higher priority tasks of service delivery. Community Transit of Delaware County encountered financial problems that subsequently caused substantial delays in technology implementation. The installation of MDTs began in September 1997 and its 18 vehicles were equipped by early 1998, at which time the project was put on hold for almost two years. Aiken County has yet to develop a viable GIS interface to the data collected by the reservation, scheduling and on-board vehicle bar code system because staff time is not available. Technology is often viewed as an "elective" or experimental project. This is especially true when a technology is largely unproven at the time of planning or installation. There is a need for transit managers to promote technology as an important, integral solution to transit systems needs and problems, rather then an experimental, frivolous project to be conducted if surplus or special funding and staff time is available.

4.3.6 System Design

<u>Open Architecture</u>

Open system architecture and ample future expansion capabilities were key system requirements at all the case study sites. The Cape Cod Regional Transit Authority illustrates this requirement. The MDTs installed in the Cape Cod vehicles are capable of using magnetic stripe cards and a variety of smart cards, and can communicate via radio, CDPD, and several other communication protocols. The CCRTA requires an open architecture for three reasons. The first reason is based on the extensive partnerships that the CCRTA has developed. The Cape Cod transit system must easily integrate with many other transit systems including the adjacent transit authority (i.e., GATRA), local taxicabs, intercity bus transportation and ferry operations, and must provide GIS data to the GeoGraphics Laboratory at Bridgewater State University. Furthermore, the Authority is exploring partnerships with banks and businesses to initiate the use of smart cards. Partnerships with other area transit operators, highway transportation systems, and radio communication users, were also a key reason for other case study sites to require an open architecture in their technology systems.

The second reason for requiring an open architecture is based on CCRTA's phased procurement approach. As the Authority becomes proficient in the current technology installation and acquires additional funding, the procurement specifications for the next component are developed. By steadfastly embracing an open architecture, they make a wider variety of technology products available in this next procurement, thereby maximizing system capabilities and competition among vendors. In the case of CCRTA, the electronic payment system to be installed and the specific transit operators to be integrated into the system are still unknown. However, they are installing MDTs that they believe have the greatest level of open architecture, i.e., compatibility with the most card and communication technologies. Again, the use of a phased procurement approach drove the open system requirements of the other case study sites, as well.

The third reason for the CCRTA open architecture requirement is based on prior system development experience. Several years ago, CCRTA tested AVL on twenty vehicles as the technology was beginning to be applied to rural transit. The contractor developed the system from "scratch," and subsequently the proprietary system was incompatible with the emerging AVL standards in transit, and the system was fraught with critical cost overruns and delays. The CCRTA project team cancelled this contract, and conducted another AVL procurement that required an open architecture. This resulted in the purchase and installation of an effective product. The leadership believes that a proven product with the highest level of open architecture is critical for developing a technology system over several years.

Infrastructure

When designing a transit technology system, the study sites emphasized the need to install and master a technology infrastructure before moving to more specialized components. This infrastructure most commonly consists of a network of personal computers with adequate processing speed and storage and a DRT software, which form the base on to which other components will be built. Again, a review of Figure 4.1 illustrates this point. All the case study sites included DRT software among the first components of a multi-year technology plan, and most sites except Aiken County and Arrowhead Transit installed DRT software as the very first component by itself. Although some transit systems have been known to successfully install an AVL system, for example, before implementing DRT software, most systems prefer to first install and master the DRT software. Systems find using the DRT software not only results in a rapid and substantial improvement in service efficiency and quality, but also helps to develop the database and functions needed to support the large amounts of data and automated functions generated by technologies such as AVL, MDTs, electronic fare systems, and identification systems.

Mobile Communication

The development of a reliable mobile, or wireless, communication system was another critical component of the required technology infrastructure, and is commonly replete with obstacles. Mobile communication provides the voice and data link between the vehicles and base station. Adequate mobile communication capacity is especially critical for those systems installing an AVL or MDT system because the AVL polling and MDT messaging dramatically increases the required amount of digital wireless throughput. Systems were often surprised at how quickly MDT and AVL (especially if the AVL function requires frequent location polling) increased the required capacity of mobile communication, and made the existing radio channel(s) inadequate. The CCRTA, CARTS, Community Transit of Delaware County, and Arrowhead Transit systems had to dedicate substantial resources to research and install an adequate mobile communication system before moving forward with AVL and DRT installations. Further, the unusually large service areas of the CCRTA, CARTS and Arrowhead Transit systems drove up the costs and also limited the communication technology options. The CCRTA had to install three new radio towers, at approximately $30,000 each in order to provide digital radio coverage in their service area for AVL and MDTs. The Arrowhead Transit system, which covers a huge 20,000 square mile service area, had few feasible communications options and consequently used a high earth orbit satellite system for mobile communications. The communication delay inherent in the satellite system caused a two to seven minute delay in messaging between vehicles and the base station that ultimately contributed to the failure of the MDT system. The fairly well proven 800-900 MHz radio band and CDPD (cellular digital packet data) wireless systems for mobile data communications were not available to Arrowhead Transit.

There are other obstacles. Licensing a new radio frequency can take several months and often few adequate frequencies are available in, or close to, large urban areas. After the CCRTA determined that operating voice and digital data communication on the same radio channel was not working well, they were not certain whether a new radio channel could be licensed in an acceptable period of time given the competition for radio frequencies in the nearby Boston and Providence, Rhode Island areas. The AVL and MDT technology installations appeared to be on hold, indefinitely. However, the system "lucked out" and an area emergency service agency transferred an unused radio channel to it.

The wireless technologies and accompanying communication interface software have a reputation for being sensitive and error prone, especially for configurations with little operational experience. Arrowhead Transit provides a prime example of a communication problem resulting from a novel configuration of software, hardware and communication protocols. Arrowhead Transit anticipated a two to three minute delay in messages getting from the dispatch base to the vehicles using the high orbit satellite communication system. However, unacceptable five to seven minute delays were encountered during testing, and the software controlling the communication to the MDTs was prone to send messages to the wrong vehicle.

Low-Cost Solutions

Aiken County was the only case study site that installed what can be considered a low-cost solution, and the results have been impressive. The system of computer-assisted DRT software and on-board bar code scanners for the fleet of 15 vehicles cost only $30,000, and took only four days to install. Additional vehicle scanners can be added to the system for only $1,050 each. The benefits are substantial. The transit system reduced the time to gather trip information from 8 hours per day to 2 hours per day. Furthermore, the software/scanner system automatically provides a wealth of information in a relational database format that Aiken County plans to use for improving client case management, and analyzing routing and client demographic information (using GIS).

Given the installation success and benefits of the Aiken County technology system, there seems to be a need for an inexpensive, low-technology software/hardware system that meets the less complex needs of small community transportation systems. These needs are to assist in call-taking, printing manifests, automatically collecting trip data, capably generating billing and funding reports, and providing standard interfaces to other technologies such as GIS. Some state DOTs and agencies have met these requirements by developing simple transit applications and databases using standard computer application development software. However, these custom applications often do not have ongoing, quality maintenance and technical support, upgrades to meet changing transit requirements, and reliable integration with other components such as MDTs and GIS. A low-cost, less complex software system seems to have a waiting niche in the rural and small urban marketplace, and could produce substantial benefits.

4.3.7 Procurement Approach

Single Integrator

Study sites favored using a single vendor that integrated and was responsible for the various technology components of a procurement and installation. They expressed the desire to have a single source responsible for problem resolution, and many did not believe they had the in-house technical skills to successfully coordinate and integrate the various products. In some cases, one of the product vendors served in this capacity, in other cases, an expert not associated with a product was the lead integrator.

Using a system integrator can be more costly. The higher cost is based on the integrator's need to cover management time and system risk costs. In an attempt to reduce costs, CARTS did not use a single vendor and ultimately regretted that decision. Management decided to split the procurement into three separate components and serve as the overall project manager for integrating the software, hardware and network configuration. They believe the results were higher overall product costs, greatly increased staff time dedicated to project management, and a reduced level of responsiveness on the part of the various vendors.

Joint Procurement

Nearly all the case study sites effectively used joint procurements. A joint procurement is when two or more systems combine their system specifications and quantities into a single procurement. These partnerships, which the systems believed reduced costs and provided bargaining leverage for product customization and technical support, were formed with a variety of types of agencies. Although some sites mentioned that joint procurements, similar to any type of partnership, made the process more complex given the need to accommodate specifications for more than one agency, the study sites unanimously heralded the overall benefits. The procurement partnerships are provided in Figure 4.5.

Figure 4.5: Joint Procurements	
Study Site	**Procurement Partners**
Arrowhead Transit	Highway maintenance agency, state police, and Minnesota DOT
CCRTA	Adjacent transit authority, university, possibly banks, retailers, and intercity and local transportation operators
CARTS	Regional utility authority for radio system
Community Transit	Funding provider, local hospital, state public transportation agencies
Flagler Senior Services	Transit operators

Product Integration

Integrating mature technology products or those deemed to have an "open architecture" does not always guarantee relatively problem-free installation and operation. Transit systems must pay careful attention as to whether or not the various components of a system have previously been integrated and successfully functioned together. The case of Arrowhead Transit provides a good lesson here. The Arrowhead design, procurement and installation process were thorough and professional, and the various DRT software, MDT, AVL and satellite communication systems were all well proven. There were no obvious shortcomings in the process. However, the various products had not been installed together previously, and consequently the satellite communication system and communication interface software experienced insurmountable problems. Fortunately, Arrowhead was following a well-modeled implementation plan that included an acceptance test, and as a result, identified these problems before full installation occurred.

4.3.8 Benefits at Study Sites

Among the six case study sites, there is no known effort to collect particular "before" and "after" data to quantify technology benefits. The systems used broad measures such as "trips per hour," anecdotal information such as "our on-time performance appears to have improved," and firm observations such as "the eight-hour daily task of entering trip data has been reduced to two hours." Nonetheless, all the case study sites, except Arrowhead Transit, which terminated the DRT software, MDT and AVL system, firmly believed the advanced technology systems were cost-beneficial, and subsequently planned to move forward to install additional components in the future. In the Arrowhead Transit case, the transit system terminated the project in the testing phase, but the other project partners, i.e., the highway maintenance division and state police, proceeded to implementation.

A summary of the technology system benefits for each case study site follows.

Aiken County Area Council on Aging

The Area Council previously had a full-time staff person dedicated to entering trip data into a database and producing billing reports. The use of the AIM Transport software and on-vehicle bar code reader system has reduced staff time to only two hours to perform these same functions, and has made more accurate data available for service evaluation purposes.

Arrowhead Transit

The interface between the MDTs and communication software failed, and therefore, Arrowhead Transit terminated the project. Arrowhead's partners, the Minnesota DOT and the state police, saw benefits and decided to continue implementation of parts of the system, and to use the partnership model that designed the system and conducted the joint procurement. These partner agencies have reduced costs through the use of joint dispatching and increased safety and public service through the use of an AVL system tracking emergency and highway maintenance vehicles.

Cape Cod Regional Transit Authority

The success of this project will be determined in several years because the MDTs, AVL and improved DRT software system are still being installed, and the connections to other transit modes and systems are still being developed. Success will be measured by the impact the completed technology system has not only on efficiency, but also on the consumption and effectiveness of intermodal passenger transportation throughout the Cape Cod region. To date, no quantitative data have been evaluated to measure impacts. However, anecdotal information and events support increased driver and passenger safety, less negative impact from employee turnover, quicker identification and correction for lost drivers, and precise information to more satisfactorily resolve customer complaints and problems.

Capital Area Rural Transportation System

CARTS has not used data to conduct a quantitative evaluation, however, reports substantial anecdotal information. Based on the new radio and DRT software system, CARTS accomplished its two principal goals: 1) reservation and scheduling staff are treating customers equally (i.e., staff do not arbitrarily give some customers better reservations and trip pick up and drop off times); and, 2) the six separate dispatch centers have been reduced to three centers. CARTS met other goals, as well, including: dispatch can communicate with all vehicles at all times; dependency on only a few staff persons has been reduced; and client files are organized. CARTS believed that there have been too many service design changes to directly attribute any change in efficiency to the new technology system.

Community Transportation of Delaware County

No specific data has been gathered to evaluate benefits because the MDTs are still being installed. Management believes that the initial 20-vehicle MDT test was successful, and has designated a goal to increase from two to three or four trips per vehicle hour. They will need a full year of post-installation data before being able to conduct a reliable quantitative analysis of the project impact. Staff has indicated that the Web TV and on-board Photo ID systems have been positive, to date.

Flagler Senior Services

Flagler Senior Services has substantially increased from a range of 2.3-2.7 to 3.1-3.4 trips per vehicle hour. At the time of the study site visit, Flagler was conducting a detailed cost analysis.

4.4 Conclusions

The case study findings provide valuable information to transit systems that are planning or installing a technology system. These findings expose some common processes or themes that lead to successful technology installations such as the importance of leadership, the value of partnerships and joint procurements, the effectiveness of training the workforce and building a technology infrastructure, and the role of an "open architecture." These findings also warn of some common pitfalls such as the transit system acting as the product integrator and project manager to reduce the overall cost of the system. Having been exposed to these important issues, transit managers and staff will have an advantage as they choose technology products, develop plans, and address installation problems in their own systems.

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5.0 RECOMMENDED TAXONOMY

This section presents a taxonomy to guide transit systems in identifying a technology that is appropriate for their mission, size, needs, and operating characteristics. Discussion begins with a review of potential transit system characteristics for organizing the taxonomy and the reasons for ultimately choosing the set of transit system needs for organizing the recommended taxonomy. At the same time that the study team was developing the draft taxonomy, the team was also conducting telephone interviews. Input from case study site visits to transit systems using APTS technologies were used to simplify and to refine the taxonomy. This section concludes with a presentation of the recommended taxonomy and guidance for its use.

Taxonomy is a classification based on relationships. The development of a taxonomy format for this study looked at relationships among key characteristics of rural and small urban transit systems. Those characteristics included transit system size, transit system operating characteristics, and needs of various users. The taxonomy serves as a tool to assist in the selection and implementation of technology solutions to meet the needs and address the operational problems of transit managers, operations staff, contracting agencies, and the customer.

There is not a single set of needs faced by rural and small urban transit operators. Some of the differing needs and problems are directly related to the characteristics of a transit system's service area and the type(s) of transit service the system provides. As such, different types of advanced technologies are needed to help solve differing needs and problems.

The taxonomy is intended to help transit managers, transportation planners, and other transportation professionals examine which advanced technology(ies) may best respond to the needs of, and provide benefits to a particular rural transit system. The taxonomy consists of a series of tables or matrices that can give important "technology screening" information to a transit manager seeking to implement an ITS technology for the first time or to upgrade an existing ITS technology to address a need or solve a problem. The taxonomy should not be used as a sole decision-making tool. More information is needed to make wise technology choices and to develop a functional APTS system design to satisfy local transit needs and objectives. As with any purchase, local conditions should be factored into the evaluation of the selection of any technology.

5.1 Previous Research in System Characteristics

Before drafting the taxonomy, team members reviewed prior work in classifying rural and small urban transit systems. Two types of classifications have been developed through previous studies—classification according to market segment and classification according to transit operating characteristics. Previous work on rural market segments formed the beginning of a classification system for identifying APTS opportunities. In addition, the literature and information gathered from transit systems directed the project team to consider transit system needs as another possible dimension to the taxonomy. Development of the taxonomy involved the following activities:

- Review of the most current documentation on rural transit services, needs, and market segments
- Identification of logical non-transit service related dimensions
- Identification of service-related dimensions that need to be recognized
- Determination of how far to take differences in these dimensions within the purposes and objective of the TCRP study
- Preparation of tables illustrating the taxonomy

5.1.1 Transit Markets

The Federal Transit Administration (FTA) conducted two studies to identify market segments for rural APTS. A transit market can be defined as a customer base sharing a particular set of demographic characteristics. The initial study, *ITS Applications for Community Transportation* performed by Dynatrend in 1996, identified a basic classification of five rural area types[2]. These five rural market segments comprised:

1. High growth, self-contained local communities
2. Slow/no growth, self-contained local communities
3. Rural to metropolitan area commutes
4. Large sparsely-populated rural areas
5. Rural tourist areas

The follow-up study, *Transit Market Segments in Rural America* prepared by Ecosometrics, Inc. in 1997, analyzed and further defined the five market segments and also added two more market segments[3]. Those two additional market segments are:

1. Small, poor, growing communities
2. Small, poor, declining communities

The seven market segments that resulted from these studies are listed and defined in Figure 5.1. Geographic and economic characteristics formed the basis for this market segmentation. Although the figure does not show crossover of market areas, some rural areas overlap market segments.

In telephone interviews, FTA staff reported that these market segments have not been officially adopted or rejected. FTA refers to these seven market segments but does not solely rely on them for classifying potential APTS applications. FTA staff related that transit system operating characteristics and level of coordination seem to provide other, perhaps better, indicators of potential APTS applications.

[2] Dynatrend, *ITS Applications for Community Transportation*, Federal Transit Administration, 1996.
[3] Ecosometrics Inc., *Transit Market Segments in Rural America*, the Volpe National Transportation Systems Center and the Federal Transit Administration, October 1997.

Figure 5.1: Rural Transit Market Segments

Transit Market Type	Percent of Rural Counties	Percent of Counties with Rural Transit	Distinguishing Characteristics
Rural to urban commutes	49.0	57.6	Adjacent to metropolitan areas; more densely developed; often manufacturing or unspecified economic base; some persistent poverty counties
Large, sparsely populated areas	12.4	46.3	Primarily located in the West; often farming based; often federal lands counties
Rural tourist areas	6.8	53.9	Emphasis on services industries; relatively high population growth; often Federal lands counties
Self-contained, low growth communities	6.8	67.3	Often farming based, characterized by persistent poverty and high welfare transfer payments
Self-contained, high growth communities	2.6	57.6	Often non-specialized or manufacturing based; relatively large counties
Small, poor, growing communities	5.9	58.7	Often manufacturing, retirement, or unspecified economic base; often smaller counties; characterized by persistent poverty and high welfare transfer payments
Small, poor, declining communities	6.6	66.5	Often farming, smaller counties; characterized by persistent poverty and high welfare transfer payments
Undetermined	9.9		

The SAIC/TransCore report titled *Rural Public Transportation Technologies: User Needs and Applications* referenced the rural market segments and concluded that the seven market segments are not the best indicators of APTS needs or opportunities[4]. During the user needs identification phase of that project, the initial five market segments were used as means of classifying rural areas and selecting transit systems for site visits. However, during interviews and focus group discussions, transit system managers responded that this classification by itself was not adequate to discriminate among the various types of rural transit operations or to adequately serve as a determinant of potential ITS program applications. While this classification can be helpful in segmenting the diverse rural market, the rural transit market segments do not adequately describe the needs and problems facing rural transit systems and, therefore, do not adequately help screen appropriate technology solutions.

In that study, a second dimension based on the type of service operated was identified as also being critical to the classification of rural transit systems. For example, the operators of fixed-route services in one market segment felt more closely allied with operators of fixed-route

[4] SAIC/TransCore, *Rural Public Transportation Technologies: User Needs and Applications*, Federal Highway Administration and Federal Transit Administration, No. FHWA-D-98-146, 1998.

services in other market segments than they did with operators of demand-responsive service in the same market segment.

Another FTA-sponsored study focused on developing guidance for rural transit operators in their APTS selection process. The *Technology Options for Small Urban and Rural Transit Operations* report, prepared by the North Carolina State University Department of Civil Engineering and the Institute for Transportation Research and Education (ITRE), provides a decision support tool to guide small urban and rural transit operators in making practical technology choices[5]. The support tool incorporated five of the seven rural market segments along with system operating characteristics as part of the criteria. A diagram of the decision tree for the detailed assessment method is shown in Appendix D.

5.1.2 Non-Transit Service Related Dimensions

The Ecosometrics, Inc. study identified seven rural transit market segments based on geographic and economic characteristics, i.e., non-transit service related dimensions, as described in Figure 5.1. That study also suggested that besides market segments and service and user needs, non-transit service characteristics may be more indicative of the appropriate application of certain types of advanced technology. Potential non-transit related characteristics include:

1. Number of persons on welfare
2. Number of persons who are below poverty
3. Number of elderly persons and disabled persons
4. Degree to which area crosses over between market segments
5. Relative distance/connectedness to a major urban area
6. Type of tourist area
7. Nature of ITS infrastructure in place or planned for the area (e.g., is there a local or state ITS plan and what does it include for the rural area?)

While all these potential characteristics seem relevant, numbers one and seven could be particularly helpful in determining potential ITS applications. The first item is important because under the Welfare Reform Act, the U.S. Congress authorized federal funds for the Job Access and Reverse Commute program. The last item is important because ITS development and deployment are a top priority of the U.S. DOT. Congress authorized millions of federal dollars to help pay for rural transit improvements including APTS technologies. The fourth and fifth items are “market” characteristics covered in the seven rural market segments.

5.2.3 Transit Service Characteristics

The *Technology Plan for North Carolina Transit Systems* developed by the Institute for Transportation Research and Education (ITRE), suggests that service characteristics should be

[5] Department of Civil Engineering and Institute for Transportation Research and Education, North Carolina State University, *Technology Options for Small Urban and Rural Transit Operations*, Federal Transit Administration, 1998.

included as major discriminators as well as type of user needs and problems[6]. ITRE developed a classification scheme and series of tables using service characteristics. For demand-responsive transit service these characteristics include: number of one-way passenger trips; percent of subscription trips; number of agency contracts; growth potential; and service area size (regional vs. single county/municipality coverage). Refer to Appendix E for the complete Technology Plan.

Based on such findings from previous research and through interviews with Federal Transit Administration staff and rural transit system managers, service related characteristics should be a principal focus of the taxonomy. These can be grouped as follows:

- Size of operation (fleet size, annual vehicle hours, passenger trips)
- Type of service (fixed-route, demand-responsive, both)
- Size and type of area served (single jurisdiction versus regional rural system with multiple jurisdictions; large, sparsely populated service area versus small urban area)
- Level of coordination (number of agencies served, number of service contracts)

System size has been determined to be a primary determinant because of the impact that it has on the nature and complexity of the operational needs and problems faced by transit systems. It also typically impacts the level of resources that will be available for use in addressing needs as well as impacting the cost-effectiveness of various technology applications.

Service area size is another important factor. According to the 1994 FTA status report, the average rural county served by transit is approximately 800 square miles in area. Rural operations provide various types of transit service to meet the diverse transportation needs of rural communities. The breakdown in 1994 was as follows:[7]

- 35 percent provide demand-responsive service only
- 31 percent provide fixed-route and demand-responsive service
- 22 percent provide demand-responsive and other types of service
- 9 percent provide fixed-route service only
- 4 percent provide an alternative type of service

5.1.4 Transit System Needs

The project team also reviewed research on transit system needs. To identify these needs, research related to both transit system needs and technology benefits were explored. In the experience of the research team, benefits are often the “flip side of the same coin” of needs. A benefit only becomes such if it is able to fulfill a need.

[6] Institute for Transportation Research and Education, North Carolina State University, *Technology Plan for North Carolina*, prepared for the N.C. Department of Transportation, Public Transportation Division, 1999.
[7] *Status Report on Public Transportation in Rural America*, Federal Transit Administration, December 1994 and TCRP A-2, 1995.

The project team, through previous research efforts, has gathered substantial information from transit managers on their perceived and/or real benefits of technologies. For example, the transit managers interviewed during the SAIC/TransCore study identified user needs as important in considering the implementation of advanced technologies.

In addition, project team members have conducted training with over 200 rural transit managers and dispatchers across the country over the past four years. Based on this training effort, the following 11 categories of needs were cited by managers as reasons for investing in technology upgrades for paratransit operations.[8]

Increase service quality for customers – time customers must spend on the telephone with the transit provider, as well as hold time, should be minimized, enhanced information services should be provided, vehicles must be routed more efficiently to reduce riding time, and customer waiting time must be reduced by providing greater accuracy on "ready time."

Increase ridership – this involves making transit service easier to understand and more attractive to riders.

Enhance the safety of the system **–** transit customers must feel secure in terms of crime, accidents, and medical emergencies.

Improve scheduling productivity (efficiency and effectiveness) – transit systems are under pressure to provide the same, or even additional, service levels and types with increasingly tight budgets.

Improve operations staff productivity/performance – more productive operations staff helps to control costs, and improve service quality and customer relations.

Generate reports and retain records – among the most time consuming tasks at a transit system are data collection, developing reports or invoices for funding agencies, operations management, and vehicle maintenance tracking. These tasks become more important as transit demand is increasingly consolidated and coordinated by a single community transportation system.

Enhance the capability to manage the transit system – demand-responsive transit is by nature difficult to manage. Managers want real time data and the capability to generate a variety of reports to help them effectively monitor, control, and manage operations.

Track maintenance – transit systems need an accurate and effective process to administer preventive maintenance programs and vehicle repairs to reduce vehicle down time and service interruptions, and minimize vehicle operational costs.

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[7] Between 1995 and 1998, the KFH Group conducted 20 workshops in 12 states, and visited over 50 rural transit systems in 7 states. Management and dispatchers that participated in these workshops and visits reported these expected benefits of paratransit software.

Assist the dispatcher in scheduling decisions – dispatchers must make critical decisions in real time. Add-on and will-call trips, as well as vehicle breakdowns, require the dispatcher to rapidly identify the appropriate vehicles. Software that can help the dispatcher to quickly find an effective solution provides valuable benefits.

Reduce dependency on a single individual – rural transit systems often have one key individual who possesses singular knowledge about the system. Most of that knowledge tends to be memorized by that individual and is unavailable to other staff when the key person is sick or on vacation. Technologies can help spread critical knowledge to additional staff, enabling the transit system to better function during those periods.

Reduce costs – software and other APTS technologies can help to reduce overall operating costs, primarily through increased staff productivity. This will also include a reduction of fraud as part of cost control.

Another useful study, *Small Urban and Rural Advanced Public Transportation Systems*[9], cites a similar, more concise set of APTS benefits. These benefits correspond very well to the more detailed eleven categories previously cited:

- More efficient customer billing process
- Greater communication (driver/dispatch, and highway/transit)
- Improved customer communications
- Reduced customer complaints
- Reduced personnel costs
- Greater staff accountability
- Improved trip scheduling

A 1999 Federal Transit Administration/Federal Highway Administration (FTA/FHWA) study, *Rural Public Transportation Technologies: User Needs and Applications,*[10] reviewed a variety of technology applications as well as benefits to customers and transit systems as presented in Figure 5.2. Again, these two sets of potential benefits correspond well with the two studies cited, and would function equally as well if categorized as a set of transit system needs, as indicated in the title of the study from which they come.

[9] Department of Civil Engineering and Institute for Transportation Research and Education, North Carolina State University, *Small Urban and Rural Advanced Public Transportation Systems*, Federal Transit Administration, 1999.
[10] SAIC/TransCore, *Rural Applications of Advanced Traveler Information Systems: Public Transportation User Needs and Applications*, Federal Transit Administration/Federal Highway Administration, 1997.

Figure 5.2: User and Transit System Benefits	
Benefits to Transit Customers	**Benefits to Transit Systems**
Improved reliability	Reduced costs
Improved safety/security	Additional resources
Reduced travel time	Improved safety/security
Improved information	Improved management capability
Fewer trip restrictions	Operating efficiencies
Ease of payment	Reduced cancellations / no-shows
	Improved trip productivity
	Improved cash flow
	More efficient use of billing information
	Reduced operating costs

The project study team made a few modifications to the eleven benefit/need categories based on the other cited studies and the team's experience working with rural transit operators. The result is a comprehensive list of twelve potential needs to be solved by application of APTS.

- More accurate, easier reporting and record keeping
- More efficient service coordination
- Safer, more accurate cash handling
- Improved operations staff performance and productivity
- More effective maintenance tracking
- Clearer communications among customers, operations, and vehicles
- More effective dispatching
- Faster, more efficient trip request processing
- Improved scheduling productivity
- Improved service quality
- Greater safety
- More accessible, more useful customer information

5.2 Potential Dimensions of a Taxonomy

Using all of the various characteristics, needs, and market segments as dimensions in the taxonomy results in a taxonomy that is difficult to use. This difficulty arises because there are dozens of tables and often little difference between the recommended technology solutions of several dimensions that have little influence on technology choices. For the sake of simplicity and effectiveness, only the most meaningful differences, or discriminators, as they relate to identifying rural APTS opportunities should be included as a dimension in the taxonomy. This section summarizes the potential taxonomy dimensions.

The most meaningful or discriminating transit related characteristics are system size, type of service operated, number of agencies served, and number of trips. These discriminators become especially influential in demand-responsive services (i.e. next day, same day, and real time passengers). As the number of vehicles, trips (especially demand-responsive trips), and agency clients increases, the operations become more complex with respect to the scheduling, routing, and dispatching functions. As these numbers increase, the scale of operations extends beyond the memory, recording and coordination capacity of the staff using manual methods. According to the North Carolina State University study and other recent research, small demand-responsive systems (fewer than 10-15 peak vehicles) often only need basic DRT software that simply assists the human scheduler in the process of assigning a trip to a vehicle. On the other hand, a system with 50 or more vehicles, or 500 total demand-responsive trips per day, may need an automated DRT software with GIS functionality to meet their system needs.[11] As the operational scale of the transit system increases, the effectiveness of the more advanced technologies increases as well.

The system needs are important also when identifying potential technology solutions. A system that has great safety or base/vehicle communications needs will want to investigate radio and cellular communication systems, and mayday systems as solutions to those needs. On the other hand, a system experiencing rapidly growing operational costs and demand-responsive trip demand may identify improved operations performance as its highest need. The needs of a transit system have a very strong influence on determining the technology solutions that may be appropriate for investigation and potential installation.

Other useful discriminators include the <u>size and type of market area served</u>, <u>growth potential</u>, and <u>types of current and potential riders</u>. The size of the service area is important because larger rural market areas often warrant more advanced technologies to locate and communicate with vehicles that are far away from the dispatch center. Growth potential of the transit system should be included in the APTS decision-making process because the future size and types of service will affect what kinds of technologies are appropriate.

Some discriminators have substantially less influence on technology choices than these more meaningful discriminators. These less influential discriminators appear to have a secondary influence on technology choices. They do not directly influence the choices but instead influence those discriminators that have the most influence such as system size, type of service operated, number of agencies served, number of trips, and system needs. For example, a market segment near a large, growing metropolitan area will tend to be relatively large and provide several service modes, characteristics that will directly influence technology choices. In a similar manner, certain demographic characteristics such as the number of elderly, welfare recipients, and workers will not directly influence technology choices but will help to determine the type and size of potential ridership, which are closely tied to technology effectiveness. Furthermore, FTA and some previous studies suggest that the non-transit related characteristics are not as important as the size, type and operating characteristics of a transit system.

Functional characteristics such as the availability of ITS infrastructure or a local or state ITS plan and funding program can impact the cost of implementing a given technology or the specific approach taken in technology implementation.

[11] Lave, R.E., Teal, R., and Piras, P. *Software Requirements for Demand-Responsive Transit—Final Report*, TCRP, 1996.

5.3 Dimensions of the Recommended Taxonomy

The study team utilized the information gathered from the telephone interviews and case study sites to refine the dimensions of the draft taxonomy. The team believes that the taxonomy should use system size and transit system needs as primary dimensions. The system size dimension involves classification into one of three major types of rural transit systems—small, medium, or large defined as follows:

1. Small rural transit system—operating fewer than 10 peak vehicles
2. Medium rural transit system—operating between 10 and 30 peak vehicles
3. Large rural transit system—operating more than 30 peak vehicles

The numbers are approximates, and were derived through study team deliberation and influenced by findings from the literature review and interviews with transit system managers.

The other primary dimension of the taxonomy is transit system needs. The consideration of needs is important because ITS technologies should only be implemented to meet identified needs and solve problems related to those needs. For this taxonomy, the needs are presented from the perspective of system management because they have primary responsibility for determining the appropriateness and applicability of ITS technologies as a means of addressing the needs of rural and small urban systems.

In addition to transit system size and needs, attention should also be focused on several secondary discriminators discussed previously, such as the type of service operated, the type of riders (human service agency or general public), the number or percentage of demand-responsive trips, and size of area served. Although these secondary discriminators will not represent a dimension, or set of categories through which the taxonomy is organized, they will be identified when they become an important influence in determining technology choices. For example, although the number of vehicles is a primary discriminator for selecting the use of MDTs, the type of service, e.g., demand-responsive, has an important influence, as well, and therefore will be noted in the taxonomy.

5.4 Taxonomy Content

The study team used the results of the telephone interviews and case study visits to refine the content of the taxonomy. There were several principal themes that arose from these interviews and visits that greatly influenced the content of the taxonomy. One of the principal themes was the use of APTS technology by transit systems to reduce the operational complexities of their service in order to improve efficiency and service quality. As the number of vehicles, trips, or routes increase, transit systems find it more difficult to efficiently route paratransit vehicles, monitor and adjust the on-time performance of fixed-route vehicles, and perform a number of other integral operational tasks. As a result, the taxonomy recommends increasingly complex technologies as the transit system size increases (which is determined in the taxonomy by the number of vehicles, and categorized as small, medium, and large).

For example, in Need #4: Improve Operations Staff Performance and Productivity, the taxonomy recommends that medium and large systems consider using either computer-assisted or automated DRT software to improve paratransit dispatching, routing, data collecting, and reporting. The study team found that small transit systems, i.e., those with less than ten vehicles, are unlikely to experience significant operations improvements from DRT software because the system staff are able to handle the scheduling, routing, and dispatching duties associated with so few vehicles. As the number of vehicles increases, the efficient completion of these duties becomes more difficult for a single person to handle, or for several people to effectively coordinate, and the operational benefits of using DRT software become substantial. In fact, large systems, i.e., those with more than 30 vehicles, are likely to require the automated scheduling and dispatching functions of an automated DRT to experience substantial improvements.

The theme of using technology to process the volume of information and simplify the coordination of large transit operations is important throughout the taxonomy. MDTs are recommended to permit the automated dispatching of large trip volume and make more efficient use of crowded radio channels. AVL is identified as a technology to help operations staff keep track of current vehicle locations and the status of vehicle on-time performance. Small and medium sized transit systems are less likely than a large system to experience a backlog of trips to be dispatched and confusion concerning vehicle locations.

Another principal study theme that significantly influenced the content of the taxonomy is the difficulty of implementing APTS technology. Transit systems experienced substantial delays in implementing DRT software, MDTs, and AVL systems because of hardware integration problems, the lack of adequate client or GIS data, and the long learning curve for staff to develop new technical skills to operate the technology system. Systems were consistently behind schedule in their technology implementation, and some systems either completely failed to implement a technology, or after the implementation experience they significantly scaled back previous plans to install subsequent APTS technologies.

Based on those experiences, the project team was careful to not recommend APTS technologies that are difficult to install in small and, in certain cases, medium size transit systems. These smaller transit systems tend to have less specialized staff, and therefore are unable to train and specifically dedicate staff to the technical duties needed to install and operate the more complex technologies. It requires technically specialized staff to manage the GIS data for an AVL system, effectively use and manage automated DRT software system, and develop and manage the integration of several sensing and data systems to operate an en-route customer information system. Smaller transit systems cannot afford the expense of hiring and training this specialized staff.

On the other hand, transit systems of all sizes appear to have realized benefits from developing customized spreadsheets and databases to support client eligibility, reservations, scheduling, vehicle maintenance, reporting, and other operational functions. These customized systems have a relatively simple structure and can be developed by staff with basic computer skills using popular off-the-shelf software packages such as Microsoft Access and Excel. This technology option is often recommended to small transit systems given their relatively simple service demands, lack of specialized staff with advanced technology skills, and limited budget.

The high cost of APTS technology is another important theme that amply influenced the resulting taxonomy. For example, an automated DRT software costs $25,000 to $55,000 and MDTs for a small system are at least $3,000 per vehicle. These costs do not include additional payroll expenses during the installation phase, required computer hardware upgrades, ongoing staff training, and other transition and operational expenses. Given these costs, only large transit systems and those fortunate enough to receive one of the limited number of technology capital grants are able to afford the costs of purchasing, installing, and maintaining APTS technology systems. The taxonomy does not recommend the more expensive technologies to small, and in certain cases to medium, size transit systems because these systems cannot afford the expense.

5.5 Use of the Taxonomy

Figure 5.4 presents the recommended taxonomy. Each table addresses a transit system need that can be addressed by the application of some form of APTS technology. Each row of the tables represents a different APTS technology or technology category that can be applied to meet one or more aspects of a particular need. Across each row, an indication is provided as to whether or not the particular technology is deemed to be appropriate for a transit system fleet size—small, medium, or large.

The column, labeled "Application," provides an indication of the applicability of the technology to particular aspects of the need in question. It also provides guidance on how the various system characteristics other than fleet size affect the usefulness or appropriateness of a particular technology. This includes consideration of service type (fixed-route, demand-responsive, or combined service), volume and type of daily ridership (number of riders, number of same day demand-responsive riders, agency clients, etc.), and size of service area.

Finally, within each need, the technologies are divided into two broad categories—basic and advanced technologies. The basic technologies tend to be those that have the potential to help solve problems for even the smallest or least complex of rural and small urban transit systems. In some case they can also be considered to be the basic building blocks upon which the more advanced technologies can be developed once a system grows or becomes more complex. The advanced technologies tend to be applicable to medium and large rural systems or systems with a high degree of complexity.

5.5.1 Definitions

Before using the taxonomy tables, it is recommended that the reader review the brief descriptions for each technology (presented in Figure 5.3) included in the tables. Appendix A provides more detailed definitions of these technologies, and of the various components that comprise the selected transit technologies.

Figure 5.3: Technology Descriptions

Technology	Use	Acronym	Description/Purpose
Automatic Passenger Counter	Fixed-Route	APC	Counts current number of passengers boarding and alighting vehicle; calculates vehicle load after pullout
Automatic Vehicle Location	Fixed-Route & Demand-Responsive	AVL	Determines vehicle location from using navigation sensors (usually GPS), commonly sending position data to base station via radio or other communication link
Accounting Software	Fixed-Route & Demand-Responsive	No acronym	Electronically processes, stores, tracks and reports standard accounting data and processes
Communications	Fixed-Route & Demand-Responsive	No acronym	Provides voice and/or digital communication among vehicles and base stations. Radio uses variety of private and commercial systems, frequency bands, and technologies. Cellular offers several commercial providers.
Customized Spreadsheet and Databases	Fixed-Route & Demand-Responsive	No acronym	Allows user to develop a computer software application to store, manipulate and report on any desired set of data such as that related to clients, schedules, trips, and billing
Demand -Responsive Transit Software *Automated*	Demand-Responsive	DRT	Expedites call taking, automatically schedules trips and routes vehicles, collects and maintains client, service and vehicle data, generates standard and customized reports
Demand-Responsive Transit Software *Computer-Assisted*	Demand-Responsive	DRT	Expedites call taking, prepares driver manifests, collects and maintains client, service, and vehicle data, and generates standard and customized reports
En-route Customer Information	Fixed-Route	No acronym	Provides real-time travel information to transit passengers and transit vehicle operators while traveling, e.g., variable message signs
Fare Media – Bar Codes – Magnetic Stripe – Smart Cards	Fixed-Route & Demand-Responsive	No acronym	Allows payment of fares without cash; cards with bar code or magnetic strip deducts fare from cash value of card; smart card deducts fare from cash value stored on embedded microchip and transfers cash value from account at bank machine or equivalent

Figure 5.3: Technology Descriptions (continued)

Technology	Use	Acronym	Description/Purpose
Geographic Information Systems	Fixed-Route & Demand-Responsive	GIS	Computer application that displays and analyzes the spatial relationship between different data such as vehicle routes, trip pickup and drop off points, bus stops, streets and landmarks
Internet Website	Fixed-Route & Demand-Responsive	No acronym	Allows personal computer users to easily exchange or display transit service information such as trip requests and route schedules and maps
Maintenance Software	Fixed-Route & Demand-Responsive	No acronym	Electronically processes, stores, tracks, and reports detailed vehicle maintenance and repair data, including parts and supplies inventory
Mayday System	Fixed-Route & Demand-Responsive	No acronym	Allows vehicle operator to trip an inconspicuous on-board switch to alert base station of an accident, crime, medical or other emergency
Mobile Data Terminal	Fixed-Route & Demand-Responsive	MDT	Serves as information link between control center and driver to relay relevant information, such as dispatch, trip, route, and rider data
Palmtop Electronic Manifest Device	Demand-Responsive	No acronym	Electronically stores and updates the vehicle schedule, i.e., manifest, for drivers, and provides capabilities similar to MDTs
Personnel Software	Fixed-Route & Demand-Responsive	No acronym	Electronically processes, stores, tracks, and reports detailed payroll, benefits, hours worked and personnel actions information
Pre-Trip Traveler Information	Fixed-Route	No acronym	Provides travel information to potential users at home, work, malls, public building, or tourist attractions prior to making their trip.
Stop Annunciators	Fixed-Route	No acronym	Provides audible and visible announcements of next stop, stop requested, etc.; can be applied on- and off-vehicle
Telephone Systems	Fixed-Route & Demand-Responsive	No acronym	Interactively route telephone calls, store messages (voice mail), notify recipients concerning new messages, or provide integrated voice response capabilities to provide information to callers on system schedules, fares and current service status.

5.5.2 Application

To apply these tables to determine available APTS options to address various needs, a transit manager should first identify the particular need in question and then refer to the appropriate table. Then the transit manager should refer to the applicable system size based on the number of vehicles operated. In determining system size, both current and projected future size, in the case of a system anticipating growth, should be considered. Next, the particular technology and its specific applicability to the need should be considered. This is where transit system characteristics other than size are factored into the evaluation. Where appropriate, the taxonomy indicates whether or not these other characteristics impact the applicability of the technology in question to the need being considered. For some needs, a given technology may only be appropriate for demand-responsive systems or only for demand-responsive systems carrying more than a given number of daily passengers, etc.

Within the taxonomy, applicable APTS technologies or system improvements have been related to specific needs and specific system characteristics based on the project team's understanding of which type of technology(ies) applies to or meets each need. These determinations are based on the interviews, site visits, and case studies conducted as part of this study effort and should be considered as general first-step guidance.

Figure 5.4: Technology Solutions by User Need

Need #1: More Accurate, Easier Reporting and Record Keeping

Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Customized Spreadsheet & Databases	☑			Easier collection, organization and reporting of any data; especially for small, fixed-route or demand-responsive systems that want low-cost or low-technical alternative to manual tracking and reporting. User must develop database and application.
Accounting Software	☑	☑	☑	Easier collection, organization and reporting of financial data; especially for systems without services of city or county government finance department. Database and application system already developed.
Personnel Software	☑	☑	☑	Easier collection, organization and reporting of wage, hour and other personnel data; especially for systems without services of city or county government human resources personnel department. Database and application system already developed.
Fare Media: Bar Code	☑	☑	☑	Automatically identifies passengers and funding agency for billing purposes.
Palmtop Electronic Manifest Device	☑	☑		Assists in collecting, merging and storing vehicle, passenger and trip data, especially for small systems not needing real time communication features of MDTs.
Advanced Technologies				
Geographic Information Systems		☑	☑	Automatically displays and analyzes location information for routing/service management; most useful for systems with more than 100 DRT trips/day, or with both fixed-route and paratransit, or with several human service agency clients.
Demand-Responsive Transit Software –Computer-Assisted		☑	☑	Assists reservation, dispatching and routing, and automates billing; especially for systems with more than 100 DRT trips/day or serving several human service agencies.
Demand-Responsive Transit Software –Automated		☑	☑	Assists reservations, automatically dispatches and routes using MDTs, GIS and AVL, and automates billing; most useful for systems with more than 300 DRT trips/day.
Fare Media: Smart Card & Magnetic Stripe Card		☑	☑	Automatically identifies passenger, and processes and stores trip data; most useful for systems with more than 200 DRT trips/day or serving several human service agencies.
Mobile Data Terminals			☑	Automatically collects, merges and stores vehicle, passenger and trip data; especially for systems with more than 300 DRT trips/day and needing automated, real time dispatching capability.

Figure 5.4: Technology Solutions by User Need (continued)

Need #2: More Efficient Service Coordination

Basic Technologies	Small System (<10 vehicles)	Medium System (10-30 vehicles)	Large System (>30 vehicles)	Application
Customized Spreadsheet & Databases	☑			Easier collection and reporting of client and trip data to support coordination, analysis of routes, modes and service; especially for small systems that want low-cost or low-technical support. User must develop database and system.
Communications	☑	☑	☑	New radio technology and arrangements, such as shared system or spectrum (i.e., trunking), FM Subcarrier and spread spectrum, offer affordable radio service. Commercial cellular offers services with relatively small equipment investment.
Fare Media: Bar Code	☑	☑	☑	Automatically identifies passengers and funding agency for billing and eligibility purposes.
Palmtop Electronic Manifest Device	☑	☑		Assist in collecting, merging and storing vehicle, passenger and trip data; especially for systems not needing real time dispatching or trip communication.
Advanced Technologies				
Geographic Information Systems		☑	☑	Automatically displays and reports trip location information for routing/service coordination analysis; most useful for systems with more than 100 DRT trips/day, serving several human service agencies, or using multiple modes to manage client mobility needs.
Demand-Responsive Transit Software –Computer-Assisted		☑	☑	Provides several mode, vehicle or route choices to meet particular trip demand, generates performance data to support coordination analysis, automatically invoices; especially for systems with more than 100 DRT trips/day, serving many human service agencies, or using multiple modes to manage client mobility needs.
Demand-Responsive Transit Software –Automated		☑	☑	Same as computer-assisted DRT except provides automated routing, and real time dispatching to MDTs; for systems with more than 300 DRT trips/day.
Automatic Passenger Counter		☑	☑	Automatically collects passenger boarding and alighting data by stop, providing more precise information to support coordination decisions; for fixed-route with 10 or more vehicles.
Fare Media: Smart Card & Magnetic Stripe Card		☑	☑	Automatically identifies passenger; processes and stores trip data, and bills/charges client or agency; most useful for systems with more than 200 DRT trips/day, and multiple service modes.
Mobile Data Terminals			☑	Automatically collects, merges and stores vehicle, passenger and trip data; especially for systems with more than 300 DRT trips/day, and needing automated, real time dispatch capability.
Automatic Vehicle Location			☑	Displays vehicle location for real time dispatching and management of passenger transfers; most useful for systems with more than 25 vehicles.

Figure 5.4: Technology Solutions by User Need (continued)				
Need #3: Safer, More Accurate Cash Handling				
Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Customized Spreadsheet & Databases	☑			Easier collection, comparison and reporting of trip and cash receipt data; especially for small systems that want low-cost or low-technical alternative to manual collection, counting and tracking. User must develop database and system.
Fare Media: Bar Code	☑	☑	☑	Automatically identifies passengers and funding agency for billing purposes.
Palmtop Electronic Manifest Device	☑	☑		Assist in collecting vehicle, passenger and trip data for billing (reducing/eliminating cash handling), and possible interface with credit, magnetic strip or smart card reader; especially for small systems not needing real time communication features of MDTs.
Advanced Technologies				
Fare Media: Smart Card & Magnetic Stripe Card		☑	☑	Automatically identifies passenger and deducts fare from card balance or collects needed billing data, reducing/eliminating cash handling; most useful for systems with more than 200 DRT trips/day, multiple service modes, or serving several human service agencies.
Mobile Data Terminals			☑	Automatically collects vehicle, passenger and trip data for billing (reducing/eliminating cash handling), and uses credit, magnetic stripe and smart cards; especially for systems with more than 300 DRT trips/day, and needing automated, real time dispatching capability.

Figure 5.4: Technology Solutions by User Need (continued)

Need #4: Improve Operations Staff Performance and Productivity

Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Customized Spreadsheet & Databases	☑			Easier collection, organizing, reporting and analysis of operations data to support staff functions; especially for small, fixed-route or demand-responsive systems that want low-cost or low-tech. alternative to manual system. User must develop database and system.
Palmtop Electronic Manifest Device	☑	☑		Streamlines vehicle, passenger, fare and trip data collection, and reduces data collection and pick up/drop off errors; especially for small systems not needing real time communication features of MDTs.
Advanced Technologies				
Geographic Information Systems		☑	☑	Automatically displays and analyzes location information for greater dispatching and routing efficiency, and better service coordination; most useful for systems with more than 100 DRT trips/day, or with both fixed-route and paratransit, or with several human service agency clients.
Demand-Responsive Transit Software –Computer-Assisted		☑	☑	Helps manage trip demand into more efficient dispatching and routing choices, and streamlines collection and integration of client, vehicle and trip data into operations database for analysis; especially for systems with more than 100 DRT trips/day or 10 vehicles.
Demand-Responsive Transit Software –Automated		☑	☑	Automatically dispatches trips and routes vehicles, collects and integrates client, vehicle and trip data for operations database for analysis; most useful for systems with more than 300 DRT trips/day or 25 vehicles.
Mobile Data Terminals			☑	Automatically dispatches trips, and streamlines vehicle, passenger and trip data collection; especially for systems with more than 300 DRT trips/day, and needing automated, real time dispatching capability.
Automatic Vehicle Location			☑	Automatically locates vehicle for more efficient real time dispatching and routing, and supports automated dispatching; most useful for systems with more than 25 vehicles, or need for automated dispatching.

Figure 5.4: Technology Solutions by User Need (continued)				
Need #5: More Effective Maintenance Tracking				
Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Customized Spreadsheet & Databases	☑			Easier collection, organization, analysis and reporting of maintenance data, and integration with operations data (e.g., vehicle fuel efficiency); especially for small, fixed-route or demand-responsive systems that want low-cost or low-technical system. User must design database and system.
Maintenance Software	☑	☑	☑	Easier collection, organization, analysis and reporting of maintenance data, and high-end software products can integrate with operations, parts inventory, and accounting systems; variety of software suitable to different size and type of transit systems. Database and system already developed.
Advanced Technologies				
Mobile Data Terminals			☑	MDTs function as collection and communication point for AVM (Automatic Vehicle Monitoring) system that automatically collects engine readings and vehicle operations data and transmits to base station; especially for systems with more than 300 DRT trips/day, and needing automated, real time dispatching capability.

Figure 5.4: Technology Solutions by User Need (continued)				
Need #6: Clearer Communications				
Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Telephone System		☑	☑	Interactive Voice Response and Automated Distribution increases capacity to handle telephone inquiries by automatically providing route and service information to riders, and routing calls; especially for 300 DRT trips/day or 5 fixed-routes.
Communications	☑	☑	☑	New radio technology and arrangements, such as shared system or spectrum (i.e., trunking), FM Subcarrier and spread spectrum, offer affordable radio service. Commercial cellular systems offer services with relatively small equipment investment.
Palmtop Electronic Manifest Device	☑	☑		Display client address and maps (with integrated GIS) for drivers; especially for small systems not needing full features of MDTs.
Advanced Technologies				
Mobile Data Terminals			☑	Automatically communicates trip, vehicle and emergency data between driver and dispatcher, reducing radio needs and trip information errors; especially for systems with more than 300 DRT trips/day, or 25 vehicles.
Automatic Vehicle Location			☑	Automatically locates vehicle without need for driver/dispatcher voice communication; most useful for systems with more than 25 vehicles.
Mayday System			☑	Sends distress signal to base station, most effective if integrated with AVL; most useful for systems with more than 25 vehicles.

Figure 5.4: Technology Solutions by User Need (continued)				
Need #7: More Effective Dispatching				
Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Customized Spreadsheet & Databases	☑			Easier real time trip tracking and data collection; especially for small systems that don't need advanced functions of more expensive DRT software. User must develop database and system.
Communications	☑	☑	☑	New radio technology and arrangements, such as shared system or spectrum (i.e., trunking), FM Subcarrier and spread spectrum, offer affordable radio service. Commercial cellular systems offer services with relatively small equipment investment.
Palmtop Electronic Manifest Device	☑	☑		Palmtop client database and map display reduces amount of information that dispatcher needs to communicate to driver; especially for small systems not needing advanced features of more expensive MDTs.
Advanced Technologies				
Demand-Responsive Transit Software –Computer-Assisted		☑	☑	Provides real time trip and vehicle status information to simplify tracking, and support dispatch decision and vehicle management; especially for systems with more than 100 DRT trips/day or 10 vehicles.
Demand-Responsive Transit Software –Automated		☑	☑	Provides real time trip and vehicle status information to simplify tracking, and support dispatch decision and vehicle management, and automatically dispatches trips; most useful for systems with more than 300 DRT trips/day or 25 vehicles.
Mobile Data Terminals			☑	Automatically communicates and displays trip data between driver and dispatcher, reducing need for voice radio communication and trip data clarification; especially for systems with more than 300 DRT trips/day, or 25 vehicles.
Automatic Vehicle Location			☑	Automatically locates vehicle to support real time trip dispatch decision, and reduce need for driver/dispatcher voice communication; most useful for systems with more than 300 DRT trips/day or 25 vehicles.

Figure 5.4: Technology Solutions by User Need (continued)

Need #8: Faster, More Efficient Trip Request Processing

Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Customized Spreadsheet & Databases	☑			Faster reservation and eligibility check using client database, quicker vehicle availability check and trip assignment with vehicle database; especially for small systems that don't need more expensive full feature DRT software. User must develop database and system.
Telephone System		☑	☑	Automatically schedule or cancel trips using telephone system, sort and direct calls to appropriate staff person, and integrate Caller ID with database for automatic client lookup; most useful to systems with at least 300 DRT trips/day or 5 fixed-routes.
Internet Web Site		☑	☑	Rider or human service agency uses Internet to request or cancel service.
Advanced Technologies				
Pre-Trip Traveler Information	☑	☑	☑	Cable TV, Kiosk and Internet Web site provides customer and agency providers with eligibility requirements and service information, reducing amount of information exchanged by telephone.
Geographic Information Systems		☑	☑	Quickly displays pick up and drop off locations to support trip eligibility decision (ADA paratransit vs. fixed-route) and vehicle/route/service availability; most useful for systems with more than 100 DRT trips/day, both fixed-route and paratransit, or several service modes.
Demand-Responsive Transit Software – Computer-Assisted		☑	☑	Quickly take reservation, check eligibility and vehicle/route/service availability with only several keystrokes; especially for systems with more than 100 DRT trips/day, both fixed-route and paratransit, or with several service modes.
Demand-Responsive Transit Software – Automated		☑	☑	Quickly take reservation, check eligibility (by client and trip) and vehicle/route/service availability with only several keystrokes; especially for systems with more than 300 DRT trips/day, both fixed-route and paratransit, or with several service modes.

Figure 5.4: Technology Solutions by User Need (continued)				
Need #9: Improved Scheduling Productivity				
Basic Technologies	**Small System (<10 vehicles)**	**Medium System (10-30 vehicles)**	**Large System (>30 vehicles)**	**Application**
Customized Spreadsheet & Databases	☑			More efficient trip assignment to vehicle by comparing trip demand and vehicle availability databases during both reservation and routing functions, and provides data for schedule evaluation; especially for small systems that don't need advanced features of more expensive DRT software. User must develop database and system.
Advanced Technologies				
Geographic Information Systems		☑	☑	Automatically displays and analyzes location information for better trip/route matching; most useful for systems with more than 100 DRT trips/day, or with both fixed-route and demand-responsive, or with several service modes.
Demand-Responsive Transit Software – Computer-Assisted		☑	☑	Automatically compares trip demand and vehicle availability for more efficient trip assignment, and captures data for schedule evaluation; especially for systems with more than 100 DRT trips/day.
Demand-Responsive Transit Software – Automated		☑	☑	Automatically compares trip demand and vehicle availability, provides system resource impact for various trip assignment options, automatically optimizes scheduling efficiency based on user-provided criteria, and captures data for automatic schedule evaluation and reports; most useful for systems with more than 300 DRT trips/day.
Mobile Data Terminals			☑	Quick communication of trip, schedule and vehicle status permits real time scheduling and dispatching; especially for systems with more than 300 DRT trips/day, and needing fast real time scheduling capability.
Automatic Vehicle Location			☑	Automatically locates vehicles to support real time trip scheduling and dispatching; most useful for systems with more than 300 DRT trips/day or 25 vehicles, and needing real time scheduling and dispatching.

Figure 5.4: Technology Solutions by User Need (continued)				
Need #10: Improved Service Quality				
Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Customized Spreadsheet & Databases	☑			Improve scheduling and routing resulting in fewer late/missed trips and shorter ride times, and collect and organize trip and operations data to evaluate and improve service; especially for small systems that don't need advanced functions of DRT software. User must develop database and system.
Telephone System			☑	Offers customer option of scheduling or canceling trip, or receiving service information by telephone, 24 hours/day; most useful to systems with more than 300 DRT trips/day, or 10 fixed-routes.
Advanced Technologies				
Geographic Information Systems		☑	☑	Improve scheduling/routing resulting in fewer late/missed trips and shorter ride times; most useful for systems with more than 100 DRT trips/day, 5 fixed-routes, or several service modes.
Demand-Responsive Transit Software – Computer-assisted		☑	☑	Better scheduling and routing resulting in fewer late/missed trips and shorter ride times; especially for systems with more than 100 DRT trips/day.
Demand-Responsive Transit Software – Automated		☑	☑	Better scheduling and routing resulting in fewer late/missed trips and shorter ride times, quick trip eligibility determination (GIS integrated), automatically collects trip data for complaint/problem resolution; most useful for systems with more than 300 DRT trips/day.
Fare Media: Smart Card & Magnetic Stripe Card		☑	☑	Offers customer option to pay fare with card, and transit system can more easily offer fare discounts to seniors and ADA riders, and for off-peak travel; most useful for systems with more than 200 DRT trips/day, or 10 fixed-routes.
Mobile Data Terminals			☑	Quick communication of trip, schedule and vehicle status permits real time adjustment to schedule, reducing missed/late trips; especially for systems with more than 300 DRT trips/day, or needing real time dispatching capability.
Automatic Vehicle Location			☑	Automatically locates vehicle to support real time schedule adjustments and service monitoring; automatically collects vehicle location data for complaint/problem resolution; most useful for systems with more than 300 DRT trips/day or 25 vehicles, and needing real time scheduling and dispatching.
Pre-Trip Traveler Information			☑	Cable TV, Travelers' Kiosk, and Internet access to real time vehicle location, schedule, trip confirmation, and other service information; normally requires large investment in GIS, AVL and advanced computer resources to gather/distribute data.
En-Route Customer Information			☑	Variable message signs provide connector vehicle location, schedule, and other service information; normally requires large investment in GIS, AVL and advanced computer resources to gather and distribute information.

Figure 5.4: Technology Solutions by User Need (continued)				
Need #11: Greater Safety				
Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Customized Spreadsheet & Databases	☑			Easier collection, organization, reporting and trend analysis of safety data such as vehicle inspections, condition and accidents, driver training and safety performance data, and passenger incidents; especially for small systems that want low-cost or low-technical alternative to manual tracking or more expensive software. User must develop database and system.
Advanced Technologies				
Demand-Responsive Transit Software – Computer-assisted		☑	☑	Supports collection, organization, reporting and trend analysis of some safety data such as vehicle inspections, condition and accidents, driver training and safety performance data, and passenger incidents; especially for systems with more than 100 DRT trips/day, and needing DRT software to support other important functions.
Demand-Responsive Transit Software – Automated		☑	☑	Automatically collects, organizes, reports, and analyzes some safety data such as vehicle inspections, condition and accidents, driver training and safety performance data, and passenger incidents;; most useful for systems with more than 300 DRT trips/day, and needing DRT software to support other important functions.
Mobile Data Terminals			☑	Integrated with Mayday system to alert base station of vehicle accident, robbery and other problems; especially for systems with more than 300 DRT trips/day, and using MDTs to support dispatching function.
Automatic Vehicle Location			☑	Automatically locate vehicle in mayday or other distress call; especially for systems with more than 300 DRT trips/day, and using AVL to support dispatching function.
Mayday Systems			☑	Automatically alerts base station in distress situation and allows audio monitoring of situation; especially for systems with more than 300 DRT trips/day, or for vehicles in high-risk service, e.g., high crime areas or late night service.

Figure 5.4: Technology Solutions by User Need (continued)

Need #12: More Accessible, More Useful Customer Information

Basic Technologies	**Small System** (<10 vehicles)	**Medium System** (10-30 vehicles)	**Large System** (>30 vehicles)	**Application**
Customized Spreadsheet & Databases	☑			Easier collection, organization and access to client and agency data, and service, route and schedule information; especially for small systems that don't need more expensive, specialized DRT software. User must develop database and system.
Telephone System		☑	☑	Offers customer option of scheduling or canceling trip, or receiving service information, by telephone, 24 hours/day; most useful to systems with more than 300 DRT trips/day, or 10 fixed-routes.
Internet Web Site		☑	☑	Rider or human service agency uses Internet connection for real time service and eligibility information.
Advanced Technologies				
Geographic Information Systems		☑	☑	Provides customer with more accurate pick up and drop off times, fare information, service eligibility and mode choice; most useful for systems with more than 100 DRT trips/day, 5 fixed-routes, or several service modes.
Demand-Responsive Transit Software – Computer-assisted		☑	☑	Supports collection, organization and access to client and agency data, and service, route and schedule information; especially for systems with more than 100 DRT trips/day, and need for DRT software to support other important functions.
Demand-Responsive Transit Software – Automated		☑	☑	Automatically collects, organizes, and accesses client and agency data, and service, route and schedule information; most useful for systems with more than 300 DRT trips/day, and need for DRT software to support other important functions.
Fare Media: Smart Card & Magnetic Stripe Card		☑	☑	Customer may get account balance and other information in vehicle; most useful for systems with more than 200 DRT trips/day or 10 fixed-routes, and needing cards to support other important functions.
Automatic Vehicle Location			☑	Automatically provides current vehicle location to provide customer with more accurate pick up and drop off times, fare information, service eligibility and mode choice; most useful for systems with more than 300 DRT trips/day or 25 vehicles, and needing AVL to support other important functions.
Pre-Trip Traveler Information			☑	Cable TV, Travelers' Kiosk, and Internet access to real time vehicle location, schedule, trip confirmation, and other service information; requires large investment in GIS, AVL and advanced computer resources to gather/distribute information.
En-Route Customer Information			☑	Variable message signs provide connector vehicle location, schedule, and other service information; normally requires large investment in GIS, AVL and advanced computer resources to gather and distribute information.

5.5.3 Additional Factors in Technology Decisions

The taxonomy can serve as a useful "technology screening" technique for initial planning purposes. Transit system size and needs are excellent factors to begin the APTS selection process. However, more information is needed to make wise technology choices and design a functional APTS plan that satisfies local transit needs. The ultimate choice of a specific technology system also depends on other important factors such as:

- Funding availability
- Data availability (e.g., GIS base maps)
- Operating system
- State Department of Transportation technology grants, programs and plans
- Regional system architecture
- National ITS architecture[12] and TCIP standards[13]
- Compatibility with other systems/technologies
- Licensing agreements
- Inter-operability of system components
- Shared infrastructure and investment costs
- Staff and training needs
- Data and system maintenance requirements
- Capital and operating costs of the technology
- Costs/benefits

A planned or existing ITS infrastructure is another important factor that underlies any transit technology choice. For example, the existence of a quality radio communication network or mobile dispatching center in the transit system's region are important factors in the selection of technology because the network or center may offer the opportunity to develop an advanced system of MDTs at a reduced cost. Any consideration of APTS applications should be coordinated with other ITS applications that may be planned or in development for the area. These coordination efforts offer opportunities to share valuable data and technology system components, and underwrite the cost of potentially expensive technology infrastructure such as radio systems, communication networks, and base station software. ITS infrastructure should have an "umbrella" type of relationship for ARTS and APTS with common architecture and standards providing the linkage between transit and highway systems to open up these coordination efforts.

[12] The National Intelligent Transportation System (ITS) Architecture is a blueprint for building an integrated, multi-modal, intelligent transportation system. It provides a description of how technology devices and subsystems are to interact. Conformity to this architecture is a strong consideration for many federal and state agencies in awarding technology funding grants.

[13] The Transit Communications Interface Profile (TCIP) is an effort to develop national transportation communication standards. The mission of TCIP has been to define the data elements and message sets that can be specified as an open data interface for transit data interchange activities. Detailed standards and project status is available at the TCIP website, www.tcip.org.

6.0 MEASURES OF EFFECTIVENESS TO ASSESS APTS

In the previous chapter, a decision making process was outlined. Through this process, a transit manager can make a determination about the most appropriate technology(ies) to implement and build upon. A next step is to predict the potential benefits (qualitative and quantitative) of the selected technologies prior to proceeding with implementation.

The objectives of this chapter are to:

- Outline potential benefits and costs
- Review the difficulties and limitations of collecting and comparing measurement data to evaluate the effectiveness of APTS
- Discuss approaches to performance evaluations
- Present recommended evaluation approach and performance measures

It is important to note that such an evaluation should occur prior to selection and procurement as part of an effective planning process so that costs and benefits can be anticipated. An evaluation should also be conducted after implementation to assess how the technology(ies) met projected benefits and costs. This post-implementation evaluation provides the transit manager with data that can be useful in fine tuning the system and examining personnel usage in order to reach desired efficiencies.

6.1 Potential Benefits

Some benefits can be measured easily, such as direct cost savings realized through increased productivity or decreased staff, equipment, and other resource requirements. Other benefits such as improved customer satisfaction and accessible customer information are less tangible and therefore less easily quantified. They may be measured only indirectly, such as through a reduction in the number of customer complaints, a measure to which it is difficult to ascribe a quantifiable financial savings. Nonetheless, these important benefits should be included in an evaluation of the success of any APTS implementation.

In Chapter 5, 12 needs/benefits were identified and these were also then incorporated into the recommended taxonomy.

6.2 Potential Costs

Costs may be incurred in several different ways. First, there is the direct financial cost of purchasing one or more technologies. This type of cost is relatively easy to document because contracts between the transit system and technology vendor, and transit system itemized budgets often produce accurate data for these costs (refer to Figure 6.1). Second, there are additional costs that are less directly associated with the implementation, training, and maintenance of the technology(ies). Some of these costs, such as contract or budget items are easily identified and quantified. On the other hand, increases in personnel costs in the transit system and supporting

Figure 6.1: Estimated Hardware/Software Costs for Select Technologies

Product Type	Estimated Costs	Comments
Accounting software	$500 to $2,000 per user	Costs vary depending on modules required.
Automatic passenger counter (APC)	$1,200 per vehicle	System costs climb to $5,000 to $10,000 per vehicle when include base software, location devices (signposts or GPS) and training.
Automatic vehicle location (AVL) system	$1,000 to $3,000 per vehicle	Total purchase costs vary depending on interface with related devices such as DRT software and MDTs. Leased system is an additional option.
Customized client database and scheduling system	$5,000 to $10,000	Programmer cost to develop reservations/scheduling system using standard, off-the-shelf database software.
Database or spreadsheet software	$350 each	Less expensive when bundled with purchase of personal computer or software suite.
DRT software – *computer assisted*	$5,000 to $20,000	Usually priced as base system, plus fee for each user and vehicle.
DRT software – *fully automated*	$25,000 to $55,000	Usually priced as base system, plus fee for each user and vehicle.
DRT software additions • data conversion • on-site training • additional on-site support • technical support upgrades and maintenance after 1st year	 • $1,000 to $4,000 • $5,000 to $15,000 • $600 to $800 per day • 15% to 25% of software cost per year	Support and training can be 1/3 to 1/2 the total system cost.
Electronic fare payment • Smart cards • Magnetic stripe cards • Bar code reader/cards	 • Not available • Not available • $4,500 for base system, plus $700 to $1,000 for each scanner (one per vehicle)	 • Total system cost varies depending on type and extent of reader and vending system. • Total system cost varies depending on type and extent of reader and vending system. • Base system includes computer and printer; card cost is nominal.
Geographic information systems (GIS)	$1,200 per user for basic; $2,700 to $4,500 per user for routing and other advanced capabilities	Software only, does not include base map data.
Maintenance software	$500 to $1,500 per user	Costs increase with additional functions such as inventory control.
Mobile data terminal (MDTs)	$2,000 each vehicle	Includes related vehicle hardware and installation; training not included.
Palmtop computer (used instead of MDTs)	$250 per Palmtop	$850 per Palmtop when loaded with GIS mapping software.

administrative departments, such as procurement and information systems, and increased computer and communications costs in subsequent years, are difficult to accurately calculate or attribute to a technology system. Costs associated with the transition to the new technology system are especially difficult to accurately identify. Refer to Figure 6.2 for a checklist of costs, other than initial capital costs, that can be anticipated.

Little research has been conducted to establish a comprehensive examination of costs associated with implementing advanced technologies at rural public transportation systems. To better define the types of costs associated with such implementation, the project team relied on discussions with transit operators, and responses to questions in the telephone interviews. Cost categories associated with implementing advanced technologies are discussed in the following sections.

6.2.1 Hardware and Software Costs

Many APTS technologies are software driven. These costs can be high and vary depending on a variety of research, development, and marketing factors. Computers, Mobile Data Terminals (MDTs), Automatic Vehicle Location (AVL) equipment, telecommunication ports, radio communication interfaces, and all other technologies require hardware.

6.2.2 Implementation Costs

There are a number of costs associated with the implementation of technology including data conversion, installation, training, and contractor staff time and expenses. Many of these costs are typically included in software and hardware purchase prices.

6.2.3 Transit System Personnel Time

Staff must perform their regular functions while at the same time learn an entirely new process. Many staff are learning to use computers for the first time, adding to the difficulty and time required to make the transition to a new technology. Most transit systems underestimate the level of effort required to successfully implement a new technology. Systems must prepare to pay for staff overtime, temporary staffing needs, and depending on the level of sophistication, the possibility of hiring additional staff to manage the technology. These costs are typically difficult to estimate, and are typically based on anecdotal evidence. Likewise, staff time devoted to conducting the procurement process is often not accounted for in assessing costs.

6.2.4 Consultant Costs

Depending on the sophistication of the technology to be implemented, it may be necessary to secure the services of outside computer and transit consultants to assist with the procurement, selection, implementation, maintenance, and training in use of the new technology.

Figure 6.2: Costs Items Commonly Overlooked in Technology Planning

Transit System Staff

- Additional staff hours for procurement process, data entry, training, and running parallel systems
- Hire new staff with needed technology skills
- Temporary support staff

Software and Data

- Yearly maintenance and technical support fees for software
- Initial GIS base map of service area, and periodic updates

Computer and Other Hardware

- Computers or server upgrade
- Peripherals (e.g., specialized printers, oversized monitors, data backup)

Communications

- Additional radio channel/frequency
- Dedicated or dial-up telecommunication line and service fee (e.g., T1 service)
- Wireless communication fee for vehicle/base station communication (e.g., cellular fee)
- Additional telephone equipment (e.g., caller ID box, key system), lines and usage fees

Training and Support

- Consulting fees for conducting procurement (e.g., write RFP and evaluate bids)
- Consulting fees for technical services (e.g., radio/computer software interface)
- Consulting fees to address integration problems, especially if installing products that are not manufactured by the prime contractor.

6.2.5 Transition Costs

Transit systems often must change their processes and procedures to adapt to new technologies. This should be accomplished prior to implementing a new technology. Unfortunately, implementation of new technologies at times results in temporary decreases in efficiency, and in a few cases, the experience of decreased efficiencies persists to the point that management decides to terminate use of the technology system. This can be due to problems with the software/ hardware or can result from a transit system that is unprepared, resists change, and/or cannot adapt to the new technology. These costs are very difficult to estimate.

6.2.6 Ongoing support/warranty and training

The first year of maintenance support is typically provided free of charge, with costs for successive years equaling 10 to 20 percent of the initial software and/or hardware cost. Increased telecommunication user fees can be significant, as well. These high, on-going costs must be factored into the cost-benefit evaluation.

6.3 Factors in Developing Measures of Effectiveness

This study attempts to provide a "real-world" evaluation of APTS technologies. Such an evaluation would include a well-defined set of empirical measurements to help conclusively determine the extent to which a particular technology system can benefit a transit system. In an ideal methodology, the transit operator would collect operations and other data before installation and post implementation. At the pre-implementation phase, in conjunction with the performance data collection, the transit manager should set goals for improvements (i.e., producing a specific monthly report will require 2 hours less of staff time per day) and translate that when possible into costs savings (i.e., 2 hours less of staff time/day equates to $160 in savings in personnel costs/week). This data would be specific enough to determine the impact that the technology will have on the transit system.

It can be time consuming for the transit operator to gather this data. It is therefore useful for transit systems to contact other public transit systems that have already installed similar technologies, and rely on evaluation methods and available measurement data from these transit sites.

6.3.1 Data Availability

Developing meaningful measurements requires a reasonable amount of reliable, specific, validated data. This level of data quality and specificity is often missing at rural and small urban transit systems.

The data collection and reporting of these transit systems is most often driven by requirements of funding agencies. These agencies tend to focus on broader measurements, such as the "cost per trip" or "trips per vehicle hour," and therefore, the transit system lacks more specific data that may be needed to definitively relate system benefits to a technology. For example, although a system may experience an increase in the "trips per vehicle hour" after the installation and use of DRT software, there are quite possibly service changes, such as major route modifications or the initiation of service for a human service agency with easy-to-serve group subscription trips that may have also positively affected this performance measurement. Therefore, it is not possible to determine technology impacts with a great degree of certainty using broad performance measurements.

The level of experience in computerization in the rural environment is another reason for the lack of data. Many rural systems do not use computers to support their most vital functions. In conducting on-site reviews of 28 systems over the past three years, the KFH Group found that less than half (42 percent) used computers as an integral part of their dispatch functions. Collecting, using and effectively analyzing detailed performance and service data requires technical expertise in relational databases, and rural systems often are not able to afford staff time and development for such a specific function.

In many cases, new technology may provide the transit system with the more specific data needed to evaluate the technology impacts. However, this situation still leaves the system without data from the period before the technology installation required for comparison purposes. To continue with the previous example, a DRT software system can provide the detailed trip data by service type, e.g., subscription and demand-responsive, and by client group that is needed to separate the performance impacts of the DRT software and service changes. Nonetheless, the system still lacks the “before” data for comparison purposes. A comprehensive technology installation plan will often include a task to collect this “before” data. This data collection task requires staff time and other scarce resources, and as a result, this data is rarely collected. Collection of this data is especially difficult as the staff time is further stressed by the addition of tasks to prepare for and install the new technology system. Even the use of sampling techniques that reduce the collection burden are beyond the staff resources of many rural and small urban systems.

Finally, many transit managers do not believe that the collection of detailed comparison data is worth the effort. Based on their years of transit experience, managers are confident that they can use the broader measurements, such as “trips per hour,” and their observations and discussion with staff to determine the effectiveness of new technology. For example, talking with staff and observing their work can provide a manager with enough information to determine if a DRT software is speeding up and improving the call-taking and dispatching functions. Given the cost and effort to collect comparative data and the question of data validity in measuring technology implementation success, managers appear disposed to rely on broad data measures and their own observations and experience in evaluating the impact of new technology.

6.3.2 Data Reliability

The lack of reliable data can pose a problem for the data that is available. From year-to-year, there is a lack of standardization in the collection and definition of operating, management, billing, and service data in rural systems. This lack of standardization often results because transit systems are still developing their data collection practices and data definitions. For example, some transit systems are changing from reporting all miles as service miles, to only those miles traveled in revenue service. Some systems are changing and mixing billing practices based on a variety of trip factors including miles, vehicle time and flat fee rates. There are several reasons for this continued evolution of rural transit systems' data collection and definition standards. Among the greatest contributing factors are: the changing reporting requirements and service regulations of the funding agencies; and the recent trend of consolidating the transit demand of several different human service agencies into a community transit systems. As community transportation systems grow, their data collection and definition continue to change and evolve.

6.3.3 Reluctance to Collect and Provide Data

Some transit systems are reluctant to collect, provide or compare "before" and "after" data for reasons that extend beyond cost or technical issues. When a transit system provides data that can be used to compare system efficiency and effectiveness before and after technology installation, the system loses some control in the evaluation process for the technology system. The system may be concerned that another entity, such as a funding agency, client agency, or council of elected officials, that does not fully understand the project goals and timeline may use the information to undermine continued support. This concern is especially serious in projects with relatively long-term objectives. For example, a transit system installing an integrated system of DRT software, MDTs and AVL in a two-year phased project may not expect to realize noticeable benefits until the fourth year of the project. The transit system will surely be loath to collect and provide data for analyzing benefits in the first several years of the project, a time in which hardware and software, and staff training and salary costs have likely increased because of technology product, implementation, and staff training expenses.

6.3.4 Conclusions

The collection of detailed data needed to accurately evaluate the impact of transit technologies can be time-consuming. Furthermore, the data may be unreliable for such an evaluation purpose, and can be misinterpreted by funding and oversight agencies in a manner that inhibits or endangers the progress of a technology project. As a result, transit systems and managers prefer to rely on traditional broad performance measurements and the collection of anecdotal information and observations to evaluate the success of technology installations.

6.4 Proposed Measures of Effectiveness

6.4.1 Simplifying the Measures

There are many possible means of categorizing measures of effectiveness. For example, performance measures can be grouped according to the areas of potential benefit, functional criteria, cost area, operations area, or other classifications. Technology represents a solution to an identified need, and thus, this study proposes using measurements that indicate the level of response to an identified need. Transit system needs can be based on the perspective of many different stakeholders such as customers, funding agencies, system management, system employees, and local elected officials. However, the inclusion of all these needs would result in a matrix of needs and related measurements that is too large and confusing as there would often be little difference among the extensive number of needs. In order to produce an easy-to-use, meaningful format, the study team used the needs of system management to categorize measures of effectiveness because management responsibilities are very broad, and consequently, they usually encompass the interests of the other stakeholders mentioned above.

A measure of effectiveness should reflect the following two principal features:

<u>Simple to collect/readily verifiable</u> **–** determine performance measures useful to analyze. Unfortunately much of this information, such as average passenger wait time, and telephone hold time is difficult to collect, as small transit systems do not typically track these measures. ("before" data is especially difficult to collect).

<u>Directly attributable to technology</u> – Ability to identify some proof that the change in the measure resulted from the implementation of the advanced technology, and not from other factors.

Using direct, simple measurements will help to overcome the cost and reliability barriers discussed in the first part of this chapter. Unless a transit system has a funded project to collect an extensive, comprehensive set of "before" and "after" data to verify the benefits of a new technology system, the system will be well-served by using one or several of the recommended measurements.

6.4.2 Recommended Measures of Effectiveness

The measures presented in Figure 6.3 are recommended for assessing potential benefits from implementing APTS. The measures are organized by the same set of 12 transit system needs used in presenting the taxonomy in Chapter 5. Figure 6.3 is an outline of the needs and related measures, and should be useful in conceiving, organizing, and presenting a measurement system. It is not intended as a detailed worksheet. Obviously, calculating a particular measure, such as "staff time required for record keeping," requires the review of many timesheets and perhaps discussions with related administrative staff, and therefore this calculation information will not fit in the outline suggested in Figure 6.3.

These measures are not intended as a whole, complete set of measures, which all must be analyzed in order to accurately determine technology impacts. For many transit systems, it is not possible or necessary to expend the resources required to collect and analyze the data needed for all these measures. Following in the same method as the taxonomy, a transit system should select and focus on a few measures recommended for assessing the particular need that the new technology is to address.

In an ideal analysis, a transit system is to collect the measurement data for a period before and after the technology system is implemented. This data collection is often a task identified in the technology implementation plan that is developed several months before the technology is installed. However, some systems may have omitted this data collection task or were unable to expend the resources to perform the collection. In this case, there is still value to the system collecting measurement data after the technology has been installed. New technology often realizes increasing operations and performance improvements over several years because transit system management and staff become increasingly more skillful in reaping technologies' benefit, more creative in its application, and more likely to change system operations practices that multiply the benefits. Therefore, post-installation data alone can often show increasingly impressive results in meeting system needs.

Although cost-saving measures are not explicitly presented, savings are inherent in most of the measures. Many measures address a reduction in staff time to perform a specific function and other efficiency measures that will result in a cost reduction to complete various units of service such as trips or reservations.

Figure 6.3: Evaluation Tool

Indicator	Current Conditions Time Period:	Projected Improvement	Projected Cost Savings (if quantifiable)	Post- Implementation Conditions (6 months after complete installation) Time Period:
1. More accurate, easier reporting and record keeping				
Staff time required for record keeping				
Staff time required for generating reports				
Staff time required for maintaining databases and reconciling errors				
Staff/management satisfaction with reporting capabilities				
2. More efficient service coordination				
Level to which clients from different agencies are intermingled on the same service or route.				
3. Safer, more accurate cash handling				
Staff time required for handling/accounting for cash				
Amount of cash collected				
4. Improved operations staff performance				
Trips per vehicle mile & hour				
Trips per scheduler and driver				
Vehicles per dispatcher				
Number of missed trips/runs				
Percent of on-time pickups				

Figure 6.3: Evaluation Tool (continued)

Indicator	Current Conditions Time Period:	Projected Improvement	Projected Cost Savings (if quantifiable)	Post- Implementation Conditions (6 months after complete installation) Time Period:
5. More effective maintenance tracking				
Percent of Preventive Maintenance events performed on-time				
Staff time per vehicle required to track Preventive Maintenance				
Replacement and repair costs per mile				
6. Clearer communications				
Capability for fast, direct emergency communication				
Percent or number of occurrences of “waiting” dispatches between base and vehicles				
Percent of non-routine communications, e.g., missing address, lost driver				
7. More effective dispatching				
Percent or number of occurrences of “waiting” dispatches between base and vehicles				
Vehicles per dispatcher				
Trips per vehicle mile and hour, by trip type (e.g., standing order, demand-responsive)				

Figure 6.3: Evaluation Tool (continued)				
Indicator	**Current Conditions Time Period:**	**Projected Improvement**	**Projected Cost Savings (if quantifiable)**	**Post- Implementation Conditions (6 months after complete installation) Time Period:**
8. Faster, more efficient trip request processing				
Trips per scheduler				
Reservations per call taker				
Average call taking/trip reservation processing time				
9. Improved scheduling productivity				
Trips per scheduler, by trip type				
Trips per vehicle mile and hour, by trip type				
Trips per vehicle by trip type				
10. Improved service quality				
Average call taking processing time				
Average telephone call hold time (using telephone management system to record statistics)				
Number of missed trips per run				
Percent of on-time pickups				
Number of complaints and compliments per trip				
Average travel time by trip type				
Customer survey (overall satisfaction)				

Figure 6.3: Evaluation Tool (continued)				
Indicator	**Current Conditions** **Time Period:**	**Projected Improvement**	**Projected Cost Savings (if quantifiable)**	**Post- Implementation Conditions (6 months after complete installation)** **Time Period:**
11. Greater safety				
Number of vehicle and passenger accidents, and emergencies				
Emergency response time				
12. More accessible, useful customer information				
Percentage of "no show" trips				
Number of telephone information requests handled by call taker				
Customer Survey (overall satisfaction)				

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7.0 FINANCING TECHNOLOGY SOLUTIONS

Rural transit systems must often seek new and innovative ways to finance technology projects/systems for two important reasons. First, funding for technology systems commonly comes from the same sources as operations and capital funding, and therefore must compete with the ongoing service, vehicle, and other capital needs of a transit system. Second, many transit boards and managers perceive technology needs as secondary to these operations and capital funding needs. This chapter examines both the traditional and alternative funding sources and strategies that transit management uses to finance rural transit technology systems.

7.1 Funding Sources

Funding rural transit technology is in many respects similar to funding most other capital projects in rural areas. Rural transit systems must be innovative in the way they finance projects, and in many cases, may have to assemble funding from several different sources to purchase, operate, and maintain a new technology system. As one would expect, federal and state transit funds are used extensively, but there are also many alternative, non-traditional funding sources. The following section presents these traditional and alternative sources.

7.1.1 U.S. Department of Transportation Funding Sources

FTA operating and capital funding is the principal source for financing rural transit. Most state departments of transportation, which administer these funds for rural and small urban areas, allow capital and operating funding to be used for purchasing transit technology. The FTA requires a local match of 20 percent for capital assistance and 50 percent for operating assistance funding.

The FTA has funded many technology demonstration projects under the Advanced Public Transportation Systems (APTS) project which is part of the ITS initiative. These funds, which are directly administered by the FTA, are competitively awarded and have financed technology components of several of the transit systems examined in this study. For example, the Cape Cod Regional Transit Authority received $200,000 in FTA Section 26 funding to design their technology system and purchase computer hardware and network.

Also, the FTA administers the Access to Jobs program. These funds are available on a competitive basis to fund transit programs for job access, and have been used in some transit projects, e.g., Cape Cod, to fund technology projects.

The Federal Highway Administration (FHWA) administers the Congestion Mitigation and Air Quality Improvement Program (CMAQ) funds that are only targeted to air pollution non-attainment areas. Although the funds have been traditionally used for highway projects, in urban areas a Metropolitan Planning Organization, and for rural areas the state department of transportation, under certain conditions, can transfer (or “flex”) these funds to transit projects. The Cape Cod Regional Transit Authority received $150,000 and $556,000 in CMAQ funding to finance part of their AVL system and transit center, respectively. The FHWA also administers the Surface Transportation Program (STP), and National Highway System (NHS) programs that are targeted to infrastructure improvements, and can be transferred to transit technology projects. In addition, FTA Section 5309 earmarks for capital purchases could be used to provide long-term funding for technology purchases. The process of seeking a capital earmark can be lengthy and involves working with the members of Congress who typically earmark these funds.

7.1.2 Other Federal Funding Sources

Federal agencies whose service mission depends on public transportation provide grant funding for transit. These agencies include the Department of Health and Human Services, the Department of Commerce, and the Department of Housing and Urban Development. Community Transportation of Delaware County used local Community Development Block Grants (CDBG) funding to finance a component of their transit technology system. A transit system may be eligible for CDBG funds if the majority of the service area is in a low-income area. The CDBG funds are distributed locally with Federal approval. Head Start funding can be used for technology procurement that initiates or improves transportation for the clients of the program. A transit agency already coordinating or providing transportation services for a Head Start agency stands the best chance of being included in a local Head Start funding proposal.

Transit systems often do not keep abreast of these other federal funding sources because they are conditioned to focus on FTA programs, and as a result, tend to understand little of the funding policies and opportunities of these non-FTA programs. However, transit systems are increasingly finding that the effort to become familiar with these programs and forge relationships with the appropriate human service agencies pays off. These human service programs are increasingly funded on a “block grant” basis that gives local authorities much greater latitude in deciding the most effective use for the funding, and effectively reducing the number of spending restrictions. Given the importance of transportation in the delivery of human services, transit appears to be garnering a larger share of these block grant programs.

7.1.3 State Funding Sources

Many states allow state transit capital funding to be used for technology procurement and some states have specialized technology funding programs. The state of North Carolina provides an excellent example. The North Carolina legislature has designated approximately $1.5 million annually to fund transit technology projects in North Carolina. The Public Transit Division of the NC DOT, with assistance from the Institute for Transportation Research and Education (ITRE), has developed the *Technology Plan for North Carolina Transit Systems* to guide and coordinate the implementation of new technology in urban and rural transit systems. Based on this plan and supported by the technology funding, North Carolina transit systems have installed many advanced and basic technology systems, organized service bureaus to provide technical support, conducted group procurements, and begun developing regional ITS plans.

The Ohio Department of Transportation, Office of Transit, also supports technology advances through providing incentives and supporting technical assistance to smaller operations through a task order contract.

7.1.4 Local Government Funding Sources

Local government funds are often required for two important reasons. First, the funds are needed to meet required matches of Federal and state funding grants. Second, local funds are needed to purchase the on-going operation and maintenance of technology systems because the federal and state funding sources, in most cases, can only be used to purchase capital goods and related services, not the ongoing operational and administrative costs associated with the technology system after the initial installation. Examples of operational and administrative costs include usage fees for a cellular communication and database report development, respectively.

7.1.5 Private Funding Sources

Transit systems seek partnerships with other agencies, private businesses and grant foundations to expand their funding sources. Many transit systems generate revenue by providing transportation service for human service agencies and other transit agencies. These funds can be applied to purchase a technology system, especially if the technology provides the system with the new capability to extend service to a particular agency.

Local businesses can become a funding source through the purchase of services, sponsorships, and advertising or simply through donations (especially if the system is operated by a non-profit corporation). Hospitals, dialysis centers, supermarkets and retailers are often interested in contributing to transportation systems that provide transit access to their services or stores. This can be a standard business transaction in which a transit system sells a service to a business. As technologies such as smart cards, Internet services and communication systems become standard among businesses and transit agencies, the opportunities expand for a transit system to provide a technology service to businesses for a fee. An example among the case study sites is the Cape Cod Regional Transit Authority is investigating the integration of their proposed Smart card payment system with bank branches and local retail businesses.

Many systems have used private foundation grants to fund a part of their system, including ITS solutions. Foundations have a wide range of giving practices. Some want projects with specific, measurable results; some prefer capital projects, while others will provide operating expenses. These sources are very competitive, and large grants require the development of a relationship with the funding agency over several months or even years.

7.2 Financing Strategies

Financing strategies are the different methods that a transit system uses to finance the procurement of technology. These methods may include the use of one or more funding sources, as well as cost control, procurement, design and other methods to make the technology acquisition feasible.

The suitability and effectiveness of any strategy depends on a variety of factors including transit system size and needs, the complexity and cost of the technology, the type and number of agencies to benefit from the technology, and the possible funding sources. Some strategies are most appropriate for large rural transit systems, while others serve small systems best.

Furthermore, some strategies can make the planning, operation, and maintenance of a technology system more difficult. This occurs especially in systems that combine the needs and requirements of several agencies to broaden the appeal and forge partnerships among the agencies; the resulting system often has greater benefits, but is inherently more complex, as well. Transit systems trying to devise a strategy to finance their ITS applications can look at any one of these strategies or combine parts of different strategies, as appropriate.

Appeal to a Broad Audience – A project that has broad appeal is able to attract a wider variety of funding sources. A project's appeal broadens as the number and type of agencies, clients, modes, services and service area increases. Most grant funding agencies look favorably upon this broad support, impact, and commitment when making funding decisions.

Establish Partnerships – As the project appeal broadens, the possibility for partnerships increase. An agency or business that is likely to benefit from a project is more likely to contribute to funding. Human service agencies and their federal and state financiers, and local businesses are excellent candidates for partnering. State DOTs are mostly responsible for administering federal transit programs, and therefore are a very important participant in the technology planning and financing process. Certain technologies also have appeal to business. New technologies, such as smart cards and seamless communication systems that integrate radio and cellular technologies, offer the opportunity to sell services to private businesses.

Approach Incrementally – The incremental approach uses existing funding sources to purchase and install one technology component at a time. For example, a system may first purchase and become proficient using software, then set up the communications infrastructure and purchase MDTs to automate the dispatching function when funding becomes available in subsequent years. This approach is especially attractive for small transit systems that either cannot afford large, single outlays of funds or do not want to subject transit system employees and customers to major change all at one time. A transit system and state DOT will often have a long-term agreement to fund and implement a technology system using this incremental approach.

Leverage a Variety of Funding Sources – Transit systems apply for and receive funds from a number of public and private sources, from government to private foundation grants. Some rural transit systems have sold advertising and raised funds to assist in the purchase of technologies. Others have partnered with a local private technology company. Funding agencies look favorably upon transit systems that have a technology plan that has attracted funding from other sources because this other interest confirms their funding decision and helps to leverage their fund commitment.

7.3 Controlling Costs

Besides mixing and matching different funding sources, there is another set of methods that transit systems use to help finance technology procurement; reducing costs. To a certain extent, reducing costs can be considered another financing strategy because transit systems employ the methods to answer the question, “How will we finance the new technology system?” Some of these methods can be implemented by one organization, but most require a consortium or state-level effort to either share costs or conduct a group procurement. The methods discussed below were identified as having the potential to reduce technology costs and ensure that the transit system can continue to realize substantial benefits from the technology. In some cases, using one or more of these methods can be the difference between purchasing technology or doing without.

7.3.1 Group Procurement

Purchasing almost any product in quantity will result in a “discount.” This quantity discount is realized in the purchase of technologies such as computer software and hardware. State DOTs typically lead the effort for group procurements, but consortiums of transit operators increasingly are taking the initiative. In addition to lower prices, group procurements often provide a level of influence with a contractor to customize their product for the group, provide more responsive technical support, and, in some cases, locate technical support staff in close proximity to the systems. Transit systems in Maryland and North Carolina have conducted joint or “piggyback” procurements of DRT software, and based on vendor price quotes, the per unit cost appears to have been significantly reduced. Furthermore, these efforts in these two states have resulted in better coordination, installation, and technical support. Among the case study sites, the CCRTA has used its membership in a consortium of transit systems and related agencies to conduct group procurements of DRT software, MDTs, and GIS software, and ultimately save staff time and reduce costs.

7.3.2 Shared Technology

In some cases, a transit system shares technology with other transit systems or non-transit agencies. Although this method increases the requirements and capacity for the overall system, it reduces the cost for each participating agency compared to the situation in which each agency procured its own system. An excellent example of this approach is at Capital Area Rural Transportation System (CARTS). CARTS, experienced difficulties in ensuring vehicle communications over its very large service area. A local utility company that operated in the same area installed a state of the art radio communications system. The utility purposely included excess capacity in order to encourage other governmental agencies to share this unique resource. CARTS was the first agency to buy into the system, realizing far greater capacity, digital communications channels, 24-hour a day monitoring of channels, and excellent radio coverage throughout the service area. The cost was approximately the same as the previous radio system, but this new system offers far greater capabilities.

7.3.3 Less Sophisticated Technology

It is very important to understand a transit system’s needs in order to install technology that is most appropriate for that system. For example, if the system needs to collect data for reporting purposes, then the use of mobile data terminals (MDTs) that provide real time data collection and communication is an option that exceeds that system's periodic reporting requirements. The system can meet the reporting requirement using much less expensive products such as on-board palmtop computers or bar code scanning devices.

Among the sites examined in this study, the Kaufman Area Rural Transit (KART), which was part of the telephone interviews, and Aiken Area Council on Aging, which as a case study site, needed on-board data collection devices but could not afford MDTs. Instead of MDTs, they installed bar code readers that collected the required data and cost much less than an MDT system. Likewise, the state of Maryland is preparing to implement in several Maryland public transit systems new software with handheld data collection devices that record odometer readings and pick up and drop off times for each passenger. Most likely, these Maryland systems would have further benefited from receiving the real time trip data that the MDTs provide, however, the small gain in benefit from the MDT system could not justify the increased cost of such a system.

7.3.4 In-House and Local Support Staff

A number of states and transit systems have used local or in-house technical support staff to ensure a rapid response to system problems, and reduce the on-going maintenance and report development costs associated with new technologies. Larger transit systems can afford to have in-house technical support staff, but most rural systems do not have the budget or level of staff specialization to provide such in-house support. Without this in-house staff, rural transit system often must hire contracted personnel to maintain and modify their technology systems, and assist the transit staff in operating the more complex features of the system. State programs and groups of rural transit systems have consolidated their resources to develop a quality, accessible source of technical assistance for support on many different issues including developing specialized reports from the large operations databases of DRT software and MDT systems. In North Carolina, for example, the state DOT contracts with the Institute for Transportation Research and Technology (ITRE) to provide technical assistance to rural transit system for maintaining DRT software, especially for generating special reports and receiving training. A similar arrangement is currently proposed in the state of Maryland. Community Transit in Delaware County, Pennsylvania, developed a customized computer-assisted DRT software, and plans to install and support the software in several other Pennsylvania transit systems based on a state-funded program.

7.4 Financing APTS - Case Study Sites

This chapter has used examples from case study sites and additional transit systems that were investigated in the research of this report. This section presents the complete innovative financing picture for four case study sites that creatively used a variety of funding sources and financing strategies.

<u>Arrowhead Transit</u>

This project exemplifies the strategy of partnering with local highway and emergency services agencies to help reduce the overall project cost. Arrowhead used 80 percent Federal ITS Demonstration and 20 percent state Department of Transportation (DOT) funds to purchase a complex system using DRT software, MDTs and AVL. The transit system was to share the communications system, purchase the MDT and AVL system with a state highway maintenance division and the state highway patrol, and operate from the same central dispatching facility as these other two agencies. Furthermore, the Minnesota DOT managed the planning process and conducted the complex RFP. Ultimately, the project failed for the transit system (although the other two agencies perceive significant benefits for their agencies and have chosen to continue). It is uncertain whether the project would have failed if Arrowhead Transit had conducted its own specification process and RFP. However, the outcome does signal a warning that although partnering may reduce costs and open up other opportunities, partnering can also add a layer of complexity to the project design that increases the risk of failure for some participants.

Cape Cod Regional Transit Authority (CCRTA)

The CCRTA project is very broad in impact, and therefore, was able to attract a wide range of funding sources and garner strong political support. The complex system of DRT software, MDTs, AVL and an advanced payment system is to integrate with the adjacent regional transit system, intercity transit services, local taxi companies, and possibly with retail stores and banks using smart cards. Approximately 15 percent of the funds were from Federal Transit Administration (FTA) Demonstration Funds, 50 percent came from Congestion Mitigation and Air Quality Improvement Program (CMAQ) funding, and the remainder came from the following funding sources; State Mobility Assistance Program (Massachusetts), Job Access and Reverse Commute, FTA Section 5311 Intercity funds, and local businesses.

The use of public-private partnerships and the experience of key project managers have been important, as well. The consortium, that includes CCRTA, GATRA and the GeoGraphics Laboratory at Bridgewater State College, has further expanded funding sources and lowered procurement costs through group procurements. The system administrator, operations manager, and project consultant, from the GeoGraphics Laboratory, have much experience in generating interest and funding in ITS projects.

Capital Area Rural Transportation System (CARTS)

CARTS demonstrates the value in building projects one step at a time to accommodate the flow of funding, and in creating partnerships. CARTS installed the software and hardware, followed by a new radio system, and now CARTS is seeking funding for MDTs. CARTS used its FTA Section 5311 funds in combination with state public transit funding and CARTS local funds for both its original software and the radio system. CARTS is currently seeking FTA Demonstration Funds for its MDTs and is also considering using Section 5310 Elderly and Disabled Capital Assistance, through the state DOT.

Partnerships have also been essential to CARTS' successful financing. CARTS reduced costs and overcame substantial communication barriers by becoming a member of a central Texas cooperative radio network. The radio network, which is composed of government agencies, provides the technical sophistication and capacity for CARTS to communicate with vehicles over their large service area using voice communication, and in the future, using MDT digital data. Currently, CARTS is discussing with Dell Computer the joint development of needed computer interfaces.

Community Transit of Delaware County

Community Transit has employed several effective strategies to finance their technology system. Similar to CARTS, Community Transit installed their system one step at a time to accommodate the flow of funding. This funding included FTA, state, Local Community Development Block Grants (CDBG), which was almost one half of the total project cost, and private foundation sources. The transit system tapped a traditionally non-transit source of funding, the CDBG, by working with local human service agencies to develop a Web TV system that communicates trip request, schedule and status information between the transit system and human service agency, and an on-board picture identification program to ensure client eligibility.

Perhaps the most unique feature among the Community Transit strategies is the fine example of entrepreneurship. Community Transit purchased the source code and marketing rights of an existing proprietary DRT software, Rides Unlimited, and tailored the product to meet their unique needs. The transit system is installing the product, now called Queue, at four Pennsylvania transit systems with similar operations needs, and providing technical support for the product at those sites.

7.5 Summary

Financing rural transit technologies is similar to transit operations and capital financing. There are a wide variety of funding sources, but traditional federal and state capital programs and special ITS demonstrations programs continue to be the principal sources. Nonetheless, some transit managers have used innovative strategies to increase the amount and number of funding sources. One of the most successful strategies is to develop a technology system that benefits related human service agencies, highway maintenance and operations, and businesses in order to share the cost with these other interests. In fact, these other interests often have funding sources, such as block grants and CMAQ highway funding that can be used for transit purposes. Transit managers also use strategies to reduce the overall system cost or implement a larger project in phases over several years in order to deal with limited or inadequate funding situations.

There is one limitation to broadening project impacts and establishing partnerships. Integrating the requirements of several agencies into a single or related technology system generally increases the system complexity, and consequently, the risk of installation or operational failure increases. The case studies in this project appeared to have overcome many limitations and risks imposed by partnerships and broadened project scopes, and subsequently realized substantial benefits from innovative financing strategies.

8.0 CONCLUSIONS

There are many conclusions that can be drawn from this research with regard to rural transit ITS deployment. One of the most striking results of this research became evident early in the study process. The use of advanced technologies in rural and small urban transit systems is still not very common. Although transit specific technology systems have evolved over the past ten years, most rural systems that have implemented any advanced technology are at the very basic level of deployment, usually a DRT software. There simply are few rural transit systems that have implemented advanced technologies, and therefore, the project team had to intensify their search for transit systems to participate in the telephone interview process. In fact, many of the transit systems that participated in the interview process had been the subject of previous or current research projects related to transit technology. The lack of subject systems has caused this research saturation for the few systems that have advanced transit technology systems.

The three major issues associated with advanced technologies in rural areas are: 1) costs, 2) installation/integration, and 3) properly matching technology with operational needs.

8.1 Costs

One reason for the limited number of technology installations in rural areas can be attributed to the high purchase and installation costs that can drain the limited financial resources of rural systems. For example, an automated DRT software system typically costs $25,000 to $55,000, and MDTs for a small system cost at least $3,000 per vehicle (including base station and communication software). DRT software and the reoccurring annual maintenance costs continue to be on the increase. Most of the transit operations that participated in our study would not have been able to install the advanced technology systems without capital or special technology funding grants.

On the other hand, some costs of transit specific technologies are steadily decreasing. For example, today's MDTs cost less and have more functionality than those on the market only a few years ago. Furthermore, new consumer electronic products such as palmtop computers, personal data assistants (PDAs), and Web phones, are competing with MDTs in the transit market.

Grant funding financed at least some portion of the advanced technology systems studied in this research, and therefore installation of these systems would not have been possible without the funding. Although most transit systems used traditional funding sources to finance their technology purchases, such as FTA Section 5311 grant funding, some were also aggressive and creative in tapping other valuable sources. Several received special FTA ITS demonstration funds. The Cape Cod Regional Transit Authority was able to “flex” substantial CMAQ (Congestion Mitigation and Air Quality Improvement Program) funding to keep the technology plan moving forward after the first AVL/MDT acceptance test had failed. Community Transit of Delaware County was also creative in working with a medical center and human service agency to tap Department of Health and Human Services and private funding. Another transit system that had a large client in their Department of Health and Human Services was able to get funding support from this agency. If a transit manager can realistically demonstrate to the contracting agency the short-term and long-tern benefits of technology to the agency and to agency clients (passengers), more may consider contributing to the costs. Laying out the cost savings to them, in real dollars and cents, makes a powerful impression.

It can be time consuming for a transit manager to pursue the more non-traditional sources such as foundations and businesses. Effort should first be put into keeping abreast of federal and state public transportation agency demonstration monies and pursuing funding from sponsoring contracted government/private agencies. Another strong alternative is to reduce capital costs through creative partnering, i.e., joint procurements with neighboring transit agencies.

For smaller transit systems, with no plans for significant service expansion, there are limited benefits for the cost invested in advanced technologies. For example, a dispatcher can usually manage several dozen vehicles using a database or spreadsheet application and voice radio. The operations staff may envision little benefit from installing automated DRT software and an MDT system, especially knowing the financial expenditure, installation effort, and technical skill level required to install and operate an advanced technology system. For example, the Aiken County Council on Aging, serving approximately 350 daily trips with 15 vehicles, opted for a low-tech computer-aided DRT software and a bar code reader system solution. This system was appropriate for the budget, level of staff technology skills, and the operations and management needs of the system.

8.2 Installation and Integration

Installing a technology within a reasonable timeframe still appears to be a huge hurdle. Problems can occur on the operations side (i.e., failing to secure a data channel, customer data files in disarray, etc.) or on the vendor side (hardware crashes, data cannot be extracted efficiently into a report format desired by operator, project management changes during implementation, etc.).

In some of the case study sites, the delays were experienced in the procurement process, which involved developing complex functional specifications and contractual clauses required for competitive procurements. Integration issues relating to software and hardware components developed by different manufacturers were difficult to resolve even in cases when a single system integrator was responsible for overseeing the complete technology system, as was the case with Arrowhead Transit. Some of the case study sites learned that their mobile communication system (i.e., among vehicles and dispatching center) was not capable or was inadequate in transmitting both digital and analog (i.e., voice) communications. The MDT and AVL systems require digital communications, and an AVL system with frequent polling requirements can quickly consume a radio channel in larger fleets.

Data caused many delays, both going in and coming out of the database system. It often took longer for the sites to clean data and obtain missing customer data than anticipated. Many of the operators were frustrated that they were not readily able to produce desired reports from a DRT software, especially for customer billing purposes. The advent of standardized databases has provided an option to transit systems that cannot rely on the canned, customized reports of the new DRT software. Data can be exported now to a standard database or report writer software, such as Microsoft ACCESS, for custom design of reports, but some of these efforts are still thwarted because the relational databases are too complex to understand without substantial training. All these interrupt the flow of implementation and also impact the day-to-day operations.

Other key concerns relate to the lack of an open architecture of a particular product and the interconnectivity among the various communications systems. Two of the sites interviews expressed that the DRT software they procured would have worked by itself but presented problems when it came to interfacing the software with the MDTs and/or AVL. In both cases, the transit system abandoned the product and either returned to a simple database or is designing their own DRT structure in-house. The proprietary architecture of the first MDT/AVL test system at Cape Cod Regional Transit Authority (CCRTA) was instrumental in CCRTA's decision to rebid that system. While there are no open architecture designed MDTs currently on the market, CCRTA did purchase an MDT system that had a relatively high number of connectivity options for communications (i.e., radio and cellular) and input (smart cards and magnetic stripe credit cards). Another site, the Aiken County Council on Aging, has had difficulty integrating the data generated by the AIM bar code reader system with a GIS software package to assist in client service analysis.

A systems integrator, whether one of the product vendors or a technical consultant not affiliated with a product, is helpful. One transit manager indicated that he regretted trying to serve in this role and that his implementation would have gone along more smoothly if they had secured an expert to pull things together.

8.3 Operational Needs

Even if capital funding is readily available, it is still important to define operational needs and then the appropriate technology to meet those needs. If the functionality of a system installed dramatically exceeds operational needs, a manager may realize after that fact that it is too labor-intensive to use and too costly to operate (maintenance fees, training of new staff, repairs, etc.). It just may be “overkill”.

The taxonomy emphasizes the relationship between system need and the use of advanced technologies. The taxonomy shows that transit systems will want to consider MDTs and AVL if they have at least 300 demand-responsive trips per day (MDT threshold) and 25 vehicles (AVL threshold), and their service requires real-time vehicle location information. These thresholds are the point at which systems will want to begin considering such technologies. Rural and small urban transit systems are small compared to the transit systems for which some of these technologies were designed, and therefore, the technologies may present less attraction for them.

The following is one example of what can happen if needs are not clearly identified. One transit operator interviewed purchased DRT software but after it was installed and staff trained they realized they were getting more efficiencies out of their old system (database for organizing files and manual scheduling/dispatching). Their service area was so compact that they did not need an automated system offering scheduling suggestions to book/dispatch trips. They abandoned the use of the software. Another transit operator, upon arriving as transit manager at a new site where DRT software was installed, related that the staff informed him no one was using the software because training was inadequate. The software was not touched in over a year.

Many of the sites interviewed recognized the need to evaluate internal polices and procedures when installing technologies. This is an opportunity to update policies and streamline procedures to get the maximum benefits out of the technology and staff resulting in greater efficiencies and enhanced customer service.

8.4 Summary

Advanced technologies are not yet common in rural transit and have not reached the easy purchase and installation state of “plug-and-play.” On the same hand, the state of the art is no longer in the pioneer stage when advanced transit technology in rural systems was a high-risk venture with little chance for reasonable payback.

Some transit systems serve as models. For example, the Cape Cod Regional Transit Authority will serve as a model for other regional ITS efforts. They are working out their software/hardware integration issues, interfaces with applications with other public entities and the private sector, connectivity across fleets, etc. The Capital Area Rural Transportation System (CARTS) is another model because they have one of the longest track records in rural areas of using automated DRT software, and are completing integration with another component, MDTs. The Aiken County Area Council on Aging has implemented a low-tech client management application that could be a low-cost model for other smaller operations with contracted services. With such leaders, it can be anticipated that product integration will be further improved and products will be more geared to meeting rural transit systems needs. A side effect should be a reduction in costs as these components become more “plug-and-play”.

In summary, for success in implementing ITS, a transit manager should:

- Clearly define needs;
- Carefully evaluate costs;
- Be creative in identifying funding sources;
- Match the technology choice (to include low-tech and high-tech solutions) to fit operational needs;
- Conduct performance evaluations;
- Analyze integration among components;
- Obtain support from a systems integrator;
- Identify a strong in-house project manager;
- Clean and update data files;
- Modify policies and procedures;
- Build skill level of staff;
- Ensure that the procured products (s) are relatively easy to and don't overburden staff; and,
- Create the efficiencies and communication systems that enhance service to the customer.

APPENDIX A

Technology Definitions

Technology Definitions

Accounting Software - A computer program for electronically processing, storing, and tracking accounting data such as budgets, payrolls, accounts receivable, and accounts payable. The software allows the user to automatically generate management reports, invoices, and payroll checks more efficiently than manual systems.

Automated Vehicle Maintenance System - A computerized maintenance system that uses telecommunications and in-vehicle technology to automatically monitor vehicle condition, location, and safety. The condition of the vehicle and its components can be monitored in real time while the vehicle is in service. Low tolerance situations such low fuel, low oil pressure, engine problems, HVAC problems, farebox problems are flagged and dispatch is notified. The driver can activate a silent alarm in an emergency and automatically notify dispatch and the police to request immediate assistance. An automated vehicle maintenance system usually incorporates automatic vehicle location technology (AVL).

Automatic Passenger Counter (APC) - An automated means of collecting data on passenger boardings and alightings by time and location. An APC system has three basic components: a method of counting passengers; a vehicle location technology; and data management. The two most prevalent types of counters are treadle mats and infrared beams.

Automatic Vehicle Location (AVL) - A computerized system that tracks the current location of vehicles in a fleet. The location of the vehicle is determined by using satellites or radio beacons and on-board units that electronically transmit the location data to a base station. Global Positioning System (GPS) is the most prevalent location-sensing technology incorporated in AVL systems. AVL is used to assist in applications such as dispatching and schedule monitoring. AVL enables transit managers to manage transit vehicles in real time with reference to the roadway network and the planned schedule.

Collision Avoidance Systems - Sensor technology on a vehicle that helps prevent collisions between vehicles, or between vehicles and other objects or pedestrians. Visual and/or audible signals are sent to the driver as an alert that an object is in proximity to the vehicle.

Communications - Provides voice and/or digital communication among vehicles and base stations. Radio uses a variety of private and commercial systems, frequency bands, and technologies. Cellular offers several commercial providers. The most common communication types include:

> <u>CDPD (Cellular Digital Packet Data)</u> - Allows data files to be separated into a number of packets and sent through idle channels of existing cellular voice networks. CDPD and other emerging commercial cellular services offer low equipment capital and maintenance costs because the network is shared and the service provider builds and maintains the network equipment.
>
> <u>FM Subcarrier RDS</u> - The information is transmitted on available frequency sidebands of commercial FM radio stations.

Shared Spectrum or System - Transit systems may share radio frequency transmission with other users such as public safety or utilities, using trunking features that allow several users to share a channel or channels to dynamically find available transmission slots. Some systems develop a communications system, e.g., transmission towers, with these same entities and use their own frequency.

Spread Spectrum - This technology transmits low power signals to send data over several frequencies and uses "receiver intelligence" to decode and re-assemble the information.

Computer Upgrade - Purchase of new computer equipment or enhancements to existing computers to add more functionality. This could include expansion of memory or storage, or the addition of new software or hardware accessories (for example, high speed modem) to enable the computer to run new programs, access the Internet, receive and send e-mail, or operate more efficiently.

Customized Spreadsheet and Databases - An off-the-shelf-software application that performs calculations on a table of numbers, such as sums of money or dates. Businesses use spreadsheets to display financial accounts, forecast sales figures, and plan work schedules. A spreadsheet shows a grid of columns and rows on the screen. Specifically customized databases and spreadsheets can be utilized by transit operators to assist in scheduling and dispatching, general record keeping, and the preparation of various management information reports.

Demand-Responsive Transportation (DRT) Software - This transit-specific software for demand-responsive transit systems incorporates client information, call-taking, scheduling, vehicle routing, agency/client billing, and other paratransit functions. The computer assisted software versions greatly increase call-taking efficiency, and track scheduled trips and vehicles, produce agency and client invoices, and collect, manage, and report on a broad set of transit data. In addition to these functions, automated software products (with GIS-functionality) provide scheduling suggestions and route vehicles. When integrated with AVL and MDT technologies, trips can be automatically assigned and dispatched on a real time basis.

Electronic Fare Media - Allows payment of fares without cash. Electronic fare media can read, and in some cases write, information that is stored on a card. These media are expected to make payment methods more user-friendly and make accounting systems more efficient. The most promising types of electronic fare media include:

Bar Coded Cards - A type of read-only fare media in which the pattern of bars in a label represent specified data. Bar codes are most commonly used in the retail industry to identify products (i.e., UPC - Universal Product Code). As part of an electronic fare system, bar coded cards and bar code readers represents a relatively low cost method for transit systems to automatically record client, trip, trip event time, and vehicle odometer data that can be downloaded to the system computers at the end of vehicle runs. The information is then used to generate operations and management reports, and billing invoices.

Magnetic Stripe Cards - A type of electronic fare media in which information is imprinted as a magnetic stripe on cards made of heavy paper, thin plastic, or heavier plastic such as that used for standard credit and ATM cards. A number of transit operators use read-only magnetic stripe passes for buses and subways.

Smart Cards - A type of electronic fare media that use plastic cards (similar to credit or debit cards) to store and process information. Smart cards contain a microcomputer in addition to electronically erasable programmable memory (EEPROM) and read only memory (ROM). The EEPROM can be used for storing information on the cash content of the card, use history, and other data subject to change. ROM is used for storing the microprocessor's operating program as well as card identification data. The user can reuse the card and increase the cash content on the card by valid electronic transactions.

En-Route Customer Information - En-route information technologies provide travel information to transit passengers and transit vehicle operators while traveling. En-route information includes travel advisories and in-vehicle instructions for the convenience and safety of passengers. The en-route information can originate from technology located next to the roadway or at passenger exchange locations, i.e., bus stops and train stations, or from technology installed in the vehicles. En-route information technology includes variable message signs, highway advisory radio, kiosks, and stop annunciators that automatically announce the next stop using voice and visual messages using electronic communications technology.

Geographical Information System (GIS) - GIS uses an electronic map and relational database to display and analyze the spatial relationship between different data. The only common feature among these different data is location. In transit, GIS displays and can be used to analyze vehicle routes, vehicle location, trip pickup and drop off points, bus stops, streets and landmarks. DRT software is often integrated with its own GIS, or an off-the-shelf GIS, to allow the DRT to recommend trip routing and scheduling assignments. AVL is integrated with GIS to provide real-time display of vehicle location. When the public bus routes and stops are coded in the GIS, the user can locate all bus stops that are within a given distance of a specified location or determine the best route from one's residence to a specified employment location. There are off-the-shelf GIS software for personal computers that offer easy-to-use and relatively low-cost capabilities. The software needs a location identifier, such as an address or vehicle location point, and a base map on which to locate and display this identifier.

Global Positioning System (GPS) - U.S. government-owned location technology that uses signal transmitted from a network of satellites in orbit to determine an object's position through triangulation. The satellites transmit a signal to receivers that compute latitude and longitude for high-accuracy positioning. GPS works anywhere the satellite signals will reach.

Internet - A global network of computers linked together by telephone, cable, and other telecommunication services. Once a computer is connected to the Internet, users can view, send, and receive electronic mail and Web page information. Transit systems use the Internet to display route schedules and current vehicle locations, permit users to schedule trips, and allow agencies in coordinated systems to identify client eligibility, schedule trips and automatically receive billing and trip information.

Maintenance Software - A computer program for electronically processing, storing, and tracking vehicle maintenance data such as fuel, oil, and water levels, oil pressure, date and nature of inspections, component repairs and replacements, breakdowns, and mechanical and electrical problems of the vehicle. The software allows the user to develop and monitor a comprehensive maintenance plan and to more efficiently monitor the condition of vehicles, conduct preventive maintenance, and reduce vehicle breakdowns. The software can also be used to generate vehicle status reports, historical data, and maintenance summary reports for management as well as to track and update parts and supplies inventories.

Mayday System - An in-vehicle system that transmits an emergency “help” signal through either a satellite or cellular communication system to an emergency response system. The in-vehicle system has an on-board GPS location device that determines the vehicle's coordinates, which are transmitted as part of the mayday signal so emergency response providers know the vehicle’s exact location.

Mobile Data Terminals (MDTs) - These are small computer terminals in vehicles that allow drivers to receive and send text and numerical data to the operations center by radio, cellular, or satellite communications networks. MDTs reduce the amount of operator radio airtime, automatically record trip data, and allow computer automated dispatching when integrated with AVL and DRT software. MDT types range from simple, two-way alphanumeric pagers to specialized, dash-mounted units for transit, and include emerging personal data tools such as palmtop computers, personal digital assistants (PDA) and Web phones, that are broadly programmable.

Palmtop Electronic Manifest Device - A small computer that is small enough to fit in a person's palm and/or pocket. Palmtops are limited compared to full-size computers but they are practical for functions that do not require high levels of processing speed, memory, and storage and in situations where highly mobile, small devices are preferred. Palmtops store and update operator manifests, provide interactive maps, provide passenger billing and address information, and perform the same functions as MDTs, including real-time communication between the vehicle and base station of trip and client billing information.

Personnel Software - A computer program for electronically processing, storing, tracking and reporting personnel related data such as payrolls, payroll taxes, benefits, hours worked, and personnel actions.

Pre-Trip Traveler Information - Travel information that is provided to potential users at home, work, malls, public building, or tourist attractions prior to making their trip. Pre-trip information may be provided on transportation services, available modes, best routes, schedules, fares, stop locations, park-and-ride lots, special events, incidents, and delays. The most common media used are touch-tone telephones and human operators. More advanced technologies include the Internet, customized telephone information systems, pagers, personalized communication devices, cable television, electronic message boards, and kiosks.

Service Bureau - A service bureau is envisioned as a means of providing various services to small transit systems that lack in-house expertise, funds, or access to software to perform the functions themselves. These functions include GIS, vehicle maintenance software, and DRT software. The service bureau helps members develop systems and plans, maintain and better utilize software, and understand technical issues. In some cases, the service bureau directly operates a centralized software system to which members are connected by the Internet.

Stop Annunciators - Device that automatically provides audible and visible announcements of next stop, stop requested and other travel information for passengers. Commonly used on vehicles and in central passenger waiting areas. In many cases, GPS, dead-reckoning, radio beacons, or another location sensing device is used to automatically locate the vehicle and trigger the announcements.

Telephone System Upgrade - Upgrades to a property's basic telephone system to provide an improved electronic communications system. An initial step involves implementation of a system that routes telephone calls to appropriate recipients, stores messages in digitized form, and provides selected service information to callers. The most common telephone system upgrades include:

> Automated Call Distribution (ACD) - A device that distributes incoming calls to a specific group of agents based on the caller's response to several service options. For example, if the number of active calls is less than the number of agents, the next call will be routed to the agent that has been idle the longest. If all terminals are busy, the incoming calls are held in a first-in-first-out queue until an agent becomes available.
>
> Interactive Voice Recognition (IVR) - A variety of applications that provide a telephone interface for callers to interact with call distribution systems, computer databases or service messages using voice commands or touch-tone keys. The system uses specialized speech recognition software that is trained to identify key words or phrases spoken by the caller when prompted, and then respond appropriately (e.g., route the call or provide information).

APPENDIX B

Glossary

Glossary

A

Accounting Software - A computer program for electronically processing, storing, tracking and reporting accounting data.

Advance Reservation Service – Demand-Responsive Transit (DRT) reservation timing regime that requires requests for reservations to be made 24 hours or more in advance; also called Prescheduled Service. This regime permits software to analyze all scheduled trips, in a batch process, to optimize schedules and routes.

Advanced Public Transportation System (APTS) -The name of an FTA program for Intelligent Transportation Systems (ITS) that are transit oriented applications.

Algorithm - A formula or set of steps for solving a problem (usually mathematical) that ensures using the best possible solution. An algorithm must be unambiguous and must stop when the best solution is calculated. DRT software employ a set of algorithms to optimize scheduling and routing.

Alphanumeric Pagers - Two-way pagers with display screen that are integrated with software to allow basic, low-cost dispatching and trip status communication between driver and dispatcher.

Application Program - A program designed to perform a set of similar tasks, such as word processing, accounting, statistical analysis, vehicle scheduling, etc.

Application Service Provider (ASP) - Firms that rent the use of technology, usually software applications, installed and maintained on the ASP's equipment. Users connect to an ASP via the Internet or other telecommunication service. ASPs offer turn-key applications for human resources, accounting, inventory, inventory control, customer support and even additional hard drive storage space.

ASCII - Acronym for American Standard Code for Information Interchange. A standard among different software for representing the characters of the alphabet, numerical digits, punctuation, and various symbols in binary code (l's and O's). An ASCII text file is a plain text file with no special format.

Automatic Passenger Counter (APC) - An on-board, automated device that collects data on passenger boardings and alightings by time and location.

Automatic Vehicle Location (AVL) - A computerized system that tracks the current location of vehicles in a fleet using satellites or radio beacons and on-board units that communicate electronically with a base station.

Automated Vehicle Maintenance System - A computerized maintenance system that uses telecommunications and in-vehicle technology to automatically monitor vehicle condition, location, and safety on a real-time basis.

Automatic Vehicle Monitoring (AVM) - An onboard system that automatically collects engine readings and vehicle operations data. Commonly, an MDT transmits the data to a base station computer system.

B

Backup - A copy of a program or data made for protection in case the original is damaged by a software virus, computer malfunction or fire. Common backup devices include a zip drive, tape drive or CD-ROM.

Bar Coded Cards - Bar coded cards allow vehicle operator to automatically collect passenger and trip data using a hand-held computer and bar code reader.

Batch Processing - Processing, analyzing and scheduling a set of trip requests all at one time.

Baud Rate - A measure of the data transfer speed of a communication device, such as a modem, designated in bits per second. For example, modems often transfer at approximately 56,000 or 96,000 bits per second.

Benchmarking - Evaluating the relative performance of different software or hardware by measuring the computer processing time or the user effort required to perform the same set of functions.

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

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

Bus - Internal computer circuitry connecting memory, microprocessors and coprocessors. Bus performance is measured in megahertz and can create a processing bottleneck when overloaded.

Byte - A group of eight binary digits processed as a unit by a computer and used especially to represent an alphanumeric character.

C

Cache – A computer CPU stores frequently used instructions and data in the cache and retrieves them from there rather than from RAM; retrieval from RAM must pass through the relatively slower bus circuitry.

Caller Identification - Telephone service that identifies the telephone number or name of the caller.

CD-ROM (Compact Disk-Read Only Memory) - Removable optical disk that stores data and is “read” using laser light. Some personal computer CD-ROM drives can write to CD-ROM diskettes.

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

Chip - A microelectronic circuit etched onto a piece of silicon. A chip can be a microprocessor or memory device, or perform other specific tasks such as computing specialized mathematical functions.

Closed Architecture - Software or hardware product specifications that are not published. As a result, a firm must be licensed and receive technical assistance from the product owner/developer in order to develop a product to integrate with the original product. See also Open Architecture.

Collision Avoidance Systems - Sensor technology on a vehicle that alerts driver to potential collisions with vehicles, objects or pedestrians.

Compatibility - The level to which personal computers and related peripherals will communicate and function as a system.

Computer-Aided Dispatching System - See Demand-Responsive Transit Software.

Computer Upgrade - Purchase of new computer software or hardware components to enhance existing computer capabilities and functionality such as memory, storage, data transmission or graphics speed.

Computerized Dispatching - Procedure for assigning demand-responsive transit customers to vehicles. A computer makes recommendation, in either real-time or batch processing mode, on which vehicle run to place a requested trip. Computerized dispatching may use Geographic Information System (GIS) to map source and destination address for making recommendation.

Contracting; Contracting Out - A procedure followed by many organizations to contract certain functions, such as operations, to private firms. A frequent rationale for contracting is the belief that the contractor has the expertise and capital to perform the function more efficiently and economically than the organization itself.

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

Customized Database/Spreadsheet - A computer software application that performs calculations on a table of numbers as specified by the user. Transit operators can use specifically customized databases and spreadsheets to prepare schedules, record dispatching, perform general record keeping, and prepare management information reports.

D

Database - A collection of information, organized for easy analysis and retrieval. Consists of individual data elements, each of which is called a field. A collection of fields related to one entity, such as a passenger, is called a record. A collection of records is called a file.

Data Element - A single item of information such as a rider's name; also called a field. A collection of data elements related to a unique entity makes a record. See also Database.

Demand-Responsive Transit (DRT) - Generic term for a range of public transportation services characterized by the flexible routing and scheduling of relatively small vehicles to provide shared-occupancy, personalized, door-to-door, curb-to-curb, or point-to-point transportation at the user's demand; implies existence of a coordinated dispatching service; also called Paratransit, ADA, Dial-a-Ride and Flexible-Route service.

Demand-Responsive Transit (DRT) Software - Computer software that incorporates transit routes, schedules, demand responsive trip orders, and vehicle assignments to allow dispatchers to know where the vehicles are in order to more efficiently schedule and dispatch trip requests. Often integrated with AVL, GIS and MDT technologies to provide advanced system capabilities.

Dial-a-Ride -See Demand-Responsive Transit.

Digital Certificates - Attachment to a piece of Internet data, such as e-mail, Web page or order form, that acts as a security measure. Certificate verifies by means of a trusted third party, the identity of the person or entity sending the data. Allows firms to receive dependable requests and orders over the Internet.

Digital Data Communications - A regime for communicating digital data (Os and 1s) that can communicate voice data as well by translation to digital data at both the sending and receiving ends.

Disk, Diskette - A disk made of magnetic, e.g., diskette or hard drive, or optical etched material, e.g., CD-ROM, that is the most common medium for recording and storing data.

Disk Operating System (DOS) - Can refer to any computer operating system, but is most often shorthand for MS-DOS (Microsoft Disk Operating System) which is the standard for IBM-compatible personal computers. DOS is still a 16-bit operating system (i.e. relatively slower than newer systems) and does not support multiple users or multitasking.

Dispatching - The process of relaying or providing service instructions to vehicle drivers or vehicle operators. Includes assigning customers to vehicles, notifying drivers of assignments and monitoring the operation of drivers.

Driver Log - A record of vehicle trip information, such as passenger names, trip origin and destination points, and trip mileage, maintained by the driver of each vehicle.

E

Electronic Fare Media - Electronic technologies for collecting fares and identifying passengers; magnetic stripe cards, magnetic/contactless cards and smart cards

Electronic Payment Systems - Automated fare payment systems that allow passengers to pay for transportation services using electronic media such as magnetic stripe cards, credit cards, debit cards, or smart cards (card with embedded microchip). Farebox or other device reads cards and performs payment entries.

Electronic Stamp (E-Stamp) - United States Postal Service application that allows customers to have postage stamps delivered or print postage stamps at home or office, and charges customers. Has possible applications for transit tickets and fares.

En-Route Customer Information - System that provides real-time travel information to transit passengers and transit vehicle operators while traveling.

Expansion Slot - See Slot

F

Fare Box - Device for the collection of fares. Also refers to the total revenue a transportation system obtains from passenger fares and local services.

Field - See Database.

File - Comparable to a file cabinet holding data pertaining to a particular topic, for example, clients, vehicles, employees. A file contains a group of records, comparable to file folders. See also Database.

Fixed-Route - Service provide on a repetitive, fixed-schedule basis along a specific route with vehicles stopping to pick up and deliver passengers to specific locations. Each fixed route trip serves the same origins and destinations (i.e., set of bus stops), unlike demand-responsive service. Typically, fixed-route service is characterized by features such as printed schedules or timetables, designated bus stops where passengers board and disembark and the use of larger transit vehicles.

G

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

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

Geographic Information System (GIS) - GIS uses an electronic map and relational database to display and analyze the spatial relationship between different data. In transit, GIS displays and analyzes vehicle routes, trip pickup and drop off points, bus stops, streets and landmarks, and it is often integrated with DRT software and AVL systems to provide advanced system capabilities.

Geographical Information System (GIS) Service Bureau - A central GIS bureau provides assistance in compiling databases of trip origin/destination information, then utilizes that information to develop efficient subscription routes or service/mode analysis.

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

Global Positioning System (GPS) - System of devices that use signals from several satellites to determine position coordinates through triangulation. GPS works anywhere the satellite signals will reach. Combined with communication system and GIS software to form AVL system.

Graphical User Interface - Operating system that uses small cartoons called icons to represent documents, programs, or commands; a mouse click on the icon initiates the action represented by the icon.

H

Hard Drive - A large-capacity data storage device containing one or more magnetic disks driven by a motor contained in a sealed case; the principal storage device in a personal computer.

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

HTML (Hypertext Markup Language) - Popular computer meta-language (easy-to-use, general language from which specific language is created) for creating electronic documents such as Web pages.

I

Integrator - Technical firm that designs and installs systems, such as AVL or DRT automated dispatching, by integrating several software and hardware products; an integrator may not produce any of the hardware or software components used in the system.

Intelligent Transportation System (ITS) - The use of recent advances in information and electronics technology to improve the development, building, and management of the transportation infrastructure and vehicles.

Internet - System of hardware, software and telecommunications protocol that allows users to easily connect to other computer systems from all over the world to exchange or display information.

Internet Protocol Security (IPSec) - Uses the encryption of Internet Protocol (IP) packets to keep the information in them from being read by others. The packets are encoded and decoded by network hubs and routers; no special software is required.

Internet Service Provider (ISP) - Entity that provides Internet access to computer users through telephone dial-up, cable television and other telecommunication services, usually for a fee. AOL (America Online), AT&T and GTE are noted ISPs.

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

In-Vehicle Terminal - See Mobile Data Terminal.

L

Local Area Network (LAN) - See Network.

M

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

Magnetic Stripe Cards - Fare and passenger information is imprinted as a magnetic stripe on a paper or plastic card such as those used for standard credit and ATM cards. Cards are read by the farebox or other electronic device in an electronic payment system.

Mainframe Computer - Large, multi-user, multifunction computer.

Maintenance Software - A computer program for electronically processing, storing, tracking and reporting detailed vehicle maintenance and repair data, including parts and supplies inventory.

Maintenance Software Service Bureau - Central maintenance service bureau that assists small transit systems in developing comprehensive maintenance plans, and provides annual or semi-annual updates of those plans.

Mayday System - An in-vehicle system that transmits an emergency “help” and vehicle location signal through either a satellite or cellular communication system to an emergency response system.

Megabyte - Measure of the amount of data; 1 million bytes.

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

Memory - See Random Access Memory.

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

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

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

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

Mobile Data Terminals (MDTs) - Small computer terminals in vehicles that allow drivers to receive and send text and numerical data by radio signals to the operations center.

Modem Modulator/Demodulator - A device that translates computer data into signals to be sent over a telephone line (e.g., analog data) and converts incoming signals back into a form understood by the computer (i.e., digital data).

Multi-user - A computer that can be used by several operators at a time, from separate keyboard terminals.

N

Network - A set of conjoined computers that can share storage devices, peripherals and applications. Networks may be connected directly by cable, or indirectly by telephone lines and/or satellites, and can be part of an office system (LAN- local area network), campus system (wide area network), or a global web of numerous other networks.

Network Upgrade - Enhancements to a computer network to improve telecommunications between users by increased memory and telecommunications speeds.

Node - Any device that can communicate with other computers in a group of interconnected computers. Usually a node refers specifically to a computer system or terminal that is part of a network.

O

Off-the-Shelf Software - Commercial software widely available from retail stores and software vendors that does not require additional effort to customize for the customer's needs.

Open Architecture - Software or hardware product specifications that are published in order to permit other entities to develop related products that operate or integrate with it. For example, anyone can develop software to operate on an open architecture personal computer, while a firm must be licensed to develop software for the closed architecture MacIntosh computer.

Open Source Code - Unlike proprietary software, no single entity owns the source code used to create the software application. Instead, the source code is widely available, allowing anyone to make changes or improvements. Several developers often collaborate to improve, add-on, or fix bugs. A noted example of an open source code product is the Linux operating system.

Operating System - A master software program that allows the computer to run software applications; controls the flow of commands and data within the computer, and between the computer, software applications and its peripherals. Examples are Windows, DOS, UNIX, Mac-OS and Linux.

Order Taking - See Reservation Function.

P

Package - A group of programs distributed as one product.

Packet - A block of data transmitted from one computer to another on a network or on the Internet. A packet contains three parts: the data to be transmitted; the data needed to guide the packet to its destination; and, the data that corrects errors that occur through transmission. A typical transmission contains several packets.

Palmtop Electronic Manifest Device - A handheld computer that can electronically store and update a vehicle schedule, i.e., manifest, for drivers, and provides capabilities similar to MDTs.

Paratransit - Passenger transportation that, on a regular basis, provides a more flexible service than fixed route service but is more structured than the use of private automobiles. Paratransit includes demand-responsive and subscription service, taxis, limousines, carpools, vanpools, and jitney services.

Peripherals - Add-on devices that are plugged into a computer, such as CD-ROM, printers, modems and scanners.

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

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

Point Deviation - Public transportation service in which the vehicle is required to arrive at designated transit stops at a prearranged schedule, but is not given a specific route to follow between these stops. It allows curb-to-curb service for passengers who request it.

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

PowerPC - Name of a type of personal computer containing a microprocessor that is compatible with both DOS and the Macintosh operating system.

Pre-Trip Traveler Information - Travel information that is provided to potential users at home, work, malls, public building, or tourist attractions prior to making their trip.

Processor - See Microprocessor.

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

Proprietary Product (Source Code) - Software or hardware that is owned by an individual or firm. Users and developers usually are required to purchase or pay license fee to use a product or to develop another product to integrate with it.

R

Random Access Memory (RAM) - A chip containing the operating memory of a computer holding the programs and data that are currently involved in operations and can be dynamically changed (uploaded or downloaded).

Read Only Memory (ROM) - A chip containing the operating memory of a computer holding the programs and commands that can be involved in operations. These programs and commands are "burned in" and thus cannot be dynamically changed.

Real-Time Scheduling - Scheduling methods where users call for trips at the actual time they wish to be picked up; trip request and pickup without advance reservations.

Reservation Function - In DRT systems, the process of taking trip request details and verifying eligibility; reservations are recorded onto a form or computer screen.

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

Route Deviation - Public transportation in which a vehicle may deviate occasionally from a fixed-route to provide curb-to-curb service to an exclusive passenger, e.g., ADA eligible client.

Router - The part of a communications network that receives transmissions (data) and forwards them to their destination using the shortest telecommunication route available. Data may travel through multiple routers on the way to its destination, especially over the Internet.

Routing - In DRT systems, providing the precise street path to a driver or vehicle.

S

Same-Day Service - Demand-responsive reservation system that responds to a request for service within the same service day but not as quickly as immediate, real-time service. For example, a system that responds to a trip request within two to four hours.

Scheduling - Giving an estimated pick up time for a requested trip, and assigning a trip to a vehicle.

Search Engine - Internet Web site that allows user to search for Internet content, such as Web sites and Web pages, based on user-defined search terms and criteria; there is commonly no cost for use. Popular search engines include Yahoo, Google, Alta Vista and Direct Hit.

Service Bureau - A service bureau is a means of providing various services to small transit systems that lack in-house expertise, funds, or access to software to perform the activities themselves.

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

Smart Card - Electronic fare media that uses plastic cards, similar to credit cards, with an embedded microchip for storing and processing information. Used with electronic systems, such as a farebox, to pay fares.

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

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

Software, Utility - Programs that perform housekeeping functions that enhance the use of the computer and increase control and flexibility of computer use, includes anti-virus, file compression, and screensaver programs.

Source Code - The original computer language in which a software program is written; source code must be changed to modify the program.

Speech Recognition - Computer application allowing conversational access through spoken input and output. Examples include transcribing information into computer records and documents, and navigating menus in a phone answering system.

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

Stop Annunciators - Provides audible and visible announcement of next stop and stop requested.

Storage - Computer device to store data such as hard disk drive, diskette, CD-ROM and zip drive.

Subscription Service - A service in which routes and schedules are pre-arranged to meet the ongoing travel needs of riders who sign up for the service in advance and require the requested transportation on a regular basis.

T

Telephone System Upgrade - Advanced telephone systems that may interactively route telephone calls, store messages (voice mail), notify recipients concerning new messages, or provide integrated voice response capabilities to provide information to callers on system schedules, fares and current service status.

TIGER Files - Files produced by the U.S. Bureau of Census that contain demographic and digital map data of the U.S. TIGER Files display basic map features, such as streets, railroads and rivers. Private firms, such as GDT and WAVTECH, further enhance these files and sell them to transit systems and other users for use in GIS.

U

UNIX - Standard operating system that operates on personal computers and networks.

V

Variable Message Signs - Displays information and messages that can be changed on-site or remotely via traffic management systems.

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

Voice Over IP (Internet Protocol) - Emerging application that allows users to use Internet connections to firms' Web pages to converse with the firm. Saves long distance telephone charges, but requires a multi-media personal computer with a microphone or headset.

W

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

Windows - Microsoft operating software system that allows operating and application software to function using user-friendly computer windows and icons, and can operate more than one program at a time (i.e. multitasking). Windows 98, Windows NT (for networks) and Windows 2000 are the most recent versions. The features and application software compatibility with these different versions varies.

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

Work Station - A single-user minicomputer.

X

XML (Extensible Markup Language) - Popular computer metalanguage (easy-to-use, general language from which specific language is created) for creating electronic documents such as Web pages.

Z

Zip Drive - A storage device that records and reads data onto a zip disk which is a magnetic disk in a removable, sealed case; this media protocol analyzes the data and reduces, or "packs," in order that it require less storage capacity.

APPENDIX C

Literature Review

Literature search

<u>Title of Reference:</u> A Comparison of Two Deployment Strategies in Minnesota's Two Transit Field Operational Tests

Book/Periodical: Proceedings from Conference on Rural Intelligent Transportation Systems

Author: Lenz, S.B.

Date: 1996
Publisher: ITS America
Annotation: Minnesota is home to two operation field testing sites which are assessing the benefits of ITS on rural systems. Since they were at different stages, architects of the tests were able to compare and contract the planning and deployment strategies. Smart DARTS (Dakota Area Resources and Transportation for Seniors) uses ITS for county-wide deployment of paratransit services and ARTIC (Advanced Rural Transportation Information and Coordination) uses ITS in a coordinated effort among four different agencies to improve rural transit.

<u>Title of Reference:</u> A Handbook for Acquiring Demand-Responsive Transit Software

Book/Periodical: TCRP Report 18

Author: Lave, R. E.; Teal, R.; Piras, P.

Date: 1996
Publisher: Transit Cooperative Research Program; Transportation Research Board
Annotation: This handbook is intended to assist DRT providers with assessment of software needs and procurement of software to meet those needs. It provides a history of DRT services, how those services operate, and how functions of DRT software support DRT service needs.

<u>Title of Reference:</u> Advanced Public Transportation System Deployments in the United States: Update, January 1999

Book/Periodical:

Author: Casey, Robert F.

Date: 1999
Publisher: Volpe National Transportation Center, Federal Transit Administration, U.S. DOT
Annotation: This report is a compilation of existing and planned APTS technology and service deployments. A total of 551 agencies submitted information as part of the NTD (National Transportation Database).

<u>Title of Reference:</u> Advanced Public Transportation Systems: A Taxonomy, Commercial Availability and Deployment (Phase II)

Book/Periodical:

Author: Khattak, Asad; Hickman, Mark; Gould, Pierce; and Paramsothy, Thananjeyan

Date: 1997
Publisher: California Department of Transportation
Annotation: This project was two-fold. The first component is a new taxonomy of APTS technologies based on the features, functions, and impacts in transit agencies. Following the development of the new taxonomy, it was used in three surveys of various technology suppliers and transit operators, both in the planning phase and post-implementation. Suppliers were surveyed as to the availability of APTS technologies while operators were asked about APTS testing, deployment, and impacts. Researchers inquired about Advanced Traveler Information Systems (ATIS), Automatic Vehicle Location, and Computer-Aided Dispatch technologies. ATIS was found to both improve transit agency image and increase access to services. AVL/CAD was shown to improve schedule adherence and enhance security.

Title of Reference: Advanced Public Transportation Systems: The State of the Art (Update '98)

Book/Periodical:

Author: Casey, Robert F., et al.

Date: 1998
Publisher: Federal Transit Administration, U.S. DOT
Annotation: This report gives an overview of available APTS technologies. Technologies are broken down into four major categories: Fleet Management, Traveler Information, Electronic Fare Payment, and Transportation Demand Management. Also included is a section on FTA-sponsored field tests as well as APTS contact people. The goal of the authors was to increase the industry's knowledge of such technology so that it may be more widely adopted.

Title of Reference: Advanced Rural Transportation Systems: Technology Review

Book/Periodical:

Author: Stone, John and Nalevanko, Anna

Date: 1997
Publisher: Presented at the CTAA Expo 97; Ft. Lauderdale, FL
Annotation: This study examines various technologies available for implementation in rural systems. Not only were software and hardware reviewed, but the team also prepared case studies and documented the successes and failures in different cases.

Title of Reference: An Evaluation of Computer Dispatch and Related Technology Options for Small Urban and Rural Transit Operation

Book/Periodical:

Author: Nalevanko, Anna and Stone, John

Date: 1996
Publisher: Federal Transit Administration, U.S. DOT
Annotation: This report provides an overview of available computer dispatch software and how it can be integrated with other technologies. The research team identified user needs in both hardware and software, compared competing products and operational impacts of such products, and assessed capability and compatibility of various combinations of products.

Title of Reference: AVL Systems for Bus Transit: A Synthesis of Transit Practice

Book/Periodical:

Author: Okunieff, Paula E., and members of the Topic Panel

Date: 1997
Publisher: Transportation Research Board
Annotation: Addresses various aspects of developing and deploying automatic vehicle location (AVL) systems including architecture and technology, and the institutional context such as funding, procurement, staff and justification.

Title of Reference: Bellevue Smart Traveler and Cellular Telecommunications

Book/Periodical:

Author: Pieratti, Denise; Haselkorn, Mark; and Blumenthal, Cathy

Date: 1993
Publisher: Federal Transit Administration, U.S. DOT
Annotation: This report describes the Bellevue Smart Traveler project which sought to see how cellular telecommunications, voice mail, and computerized real-time information in carpools and vanpools could enhance the commuting experience. A partnership was formed between the Bellevue Transportation Management Association and McCaw Cellular One. Car pool participants and single-occupancy vehicle drivers were both surveyed as to the effects of cellular communication usage. Though the prospects for cellular use in transit could not be proved, researcher found that the study is worth expanding.

Title of Reference: Benefits Assessment of Advanced Public Transportation Systems (APTS)

Book/Periodical:

Author: Geode, Dennis

Date: 1996
Publisher: Federal Transit Administration, U.S. DOT
Annotation: This report details work performed by the APTS Program sponsored by the FTA. The Volpe Transportation Systems Center analyzed available technologies as to the "order-of-magnitude" of benefits to the transit industry. They did so by quantifying benefits of existing technologies and then projecting benefits to a national level based on reasonable assumptions of potential future applications.

Title of Reference: Intelligent Transportation Systems

Book/Periodical: U.S. DOT ITS Projects Book

Author: Compiled by the U.S. Department of Transportation Intelligent Transportation Systems (ITS) Joint Program Office
Date: 1998
Publisher: U.S. DOT
Annotation: This comprehensive report describes the different types of ITS technologies as well as programs of planning or implementation across the country. The section concerning Advanced Rural Transportation Systems (ARTS) begins with an introduction which gives an explanation of the ARTS program and an overview of transportation needs unique to rural settings. Projects are then described in detail under the following sub-categories: Research and Development, Operational Tests, and Completed Projects.

Title of Reference: Effective Rural ITS Outreach: The California Program for Advancing Rural Transportation Technology Experience
Book/Periodical: Abstracts for ITS America Seventh Annual Meeting and Exposition; Washington, DC

Author: Albert, S.

Date: 1997
Publisher: ITS America
Annotation: The purpose of this report is to broadly document the transportation needs and concerns of California's rural transportation system; identify possible advanced transportation technologies to enhance the safety and efficiency of those systems; review national and California rural research initiatives; identify key issues and potential funding opportunities; and recommend conceptual ideas for further activities. The goal of this project is to provide background for building a successful Intelligent Transportation Systems (ITS) program that meets stakeholder needs.

Title of Reference: Feasibility of Intelligent Transportation System Applications in Rural California

Book/Periodical:

Author: Albert, S.; McGowen, P.

Date: 1997
Publisher: California Department of Transportation
Annotation: The purpose of this report was to provide the California Department of Transportation direction for the Program for Advancing Rural Transportation Technologies (PARTT), which is the rural component of the Advanced Transportation Systems Program. This report contains prioritized stakeholder input on problems and advanced technology solutions, based on a workshop conducted in Bishop, California. The report also examines potential Advanced Rural Transportation System applications in northern California. The study recommends short term and long term deployment strategies; research and development; funding opportunities; and next steps to build a successful Intelligent Transportation System that meets stakeholder needs.

Title of Reference: FM Subcarrier Coverage for ITS Applications by Prediction and Measurements

Book/Periodical: Abstracts for ITS America Seventh Annual Meeting and Exposition; Washington, DC

Author: DeMinco, N.; Arnold, J.A.

Date: 1997
Publisher: ITS America
Annotation: This paper discusses the coverage of an FM subcarrier system to be used for the broadcast of traffic data to vehicles on highways to support the Intelligent Transportation System (ITS) program. The STIC (Subcarrier Transportation Information Channel) performance was measured in a variety of reception environments in order to assist in the future prediction of STIC coverage in areas of the United States that differ dramatically in terrain and population density. The measurements which took place in the Denver, Colorado area included the following reception environments: urban high-rise, urban low-rise, rural mountain, and rural plains. The measurements of system coverage were used to verify coverage prediction techniques.

Title of Reference: Further Implementation of a Rural ATIS: Observations on the Continued Deployment of YATI

Book/Periodical: Abstracts for ITS America Seventh Annual Meeting and Exposition; Washington, DC

Author: Kurani, K.S.; Jovanis, P.P.; Dantas, L.

Date: 1997
Publisher: ITS America
Annotation: The Yosemite Area Traveler Information (YATI) system is an advanced traveler information system (ATIS) currently in a field operation test period. In contrast to the majority of ATIS systems which are being implemented in urban and suburban settings, YATI is a rural systems. The YATI system was designed with the goals of reducing traffic congestion, improving air quality, enhancing mobility, and preserving and promoting tourism in the region that contains Yosemite National Park and the surrounding National Forests, State Parks, and towns. These goals are to be met by providing real-time information regarding current weather and travel conditions, as well as the status of lodging, public transit, and recreational and camping facilities. Ultimately, the information will be provided by five information channels - changeable message signs (CMS), highway advisory radio (HAR), a traveler advisory telephone system (TATS), a network of electronic kiosks, and a YATI site on the World Wide Web. The authors report on progress in implementing the YATI system since a previous review in 1994.

Title of Reference: Implementation and Assessment of an Automated Vehicle Location Systems for Rural Transit Using GPS and UHF Radio Technologies

Book/Periodical: ITS America Seventh Annual Meeting (Preprint)

Author: Perry, Clifford; and Turnbull, Katherine

Date: 1997
Publisher: ITS America
Annotation: This report describes and evaluates a demonstration on the use of automated vehicle location (AVL) for rural transit service providers. The technology utilizes global positioning system (GPS) and ultra-high frequency (UHF) radio to communicate vehicle positions. This innovation and a wide variety of other ITS technologies is being demonstrated by the Texas A&M Intelligent Transportation Systems Research Center of Excellence in an effort to bring ITS to rural Texas transit operators.

Title of Reference: Implementation of an Automated Vehicle Location System for Rural Transit

Book/Periodical: Proceedings from Conference on Rural Intelligent Transportation Systems

Author: Perry, Clifford F. and Turnbull, Katherine

Date: 1996
Publisher: ITS America
Annotation: This report details the investigation and implementation of an AVL demonstration project in rural Texas. The AVL project is sponsored by the Texas A&M ITS Research Center of Excellence (RCE) seeks to bring ITS technology to areas in which costs would normally be prohibitive.

Title of Reference: Improving the Mobility of the Elderly and Disabled Using Advanced Transportation Technologies

Book/Periodical: Proceedings from Conference on Rural Intelligent Transportation Systems

Author: Jovanis, Paul P.; Abdel-Aty, Mohammed; Kowshik, Raghu

Date: 1996
Publisher: ITS America
Annotation: This paper summarizes the efforts made to assess the transportation needs and problems of elderly and disabled customers. The authors accomplish this by examining market segmentation and the use of new technologies.

Title of Reference: Integrating ITS Into Long Range Planning in Rural, Small Urban or Tourist Areas

Book/Periodical: ITS America Seventh Annual Meeting Preprint

Author: Scully, William and Napoitano, Thomas

Date: 1997
Publisher: ITS America
Annotation: This article describes the manner in which ITS technology was incorporated into the development of a regional plan for the Barnstable-Yarmouth area of Massachusetts. The project challenged the notion that technology is limited to urban areas. After continuous education efforts, ITS elements have been incorporated into all aspects of the plan.

Title of Reference: Integrating ITS Into Long Range Planning in Rural, Small Urban, or Tourist Areas

Book/Periodical: Abstracts for ITS America Seventh Annual Meeting and Exposition

Author: Scully, W.J.

Date: 1997
Publisher: ITS America
Annotation: The Barnstable-Yarmouth area of Massachusetts, including the Village of Hyannis, is a unique location of Cape Cod. The two communities together with the area's major air, rail, water and bus transportation providers conducted a major, comprehensive transportation study to develop a multi-modal plan to address congestion and growth. The integration of ITS in an environment like the Cape has required a strong, continuous emphasis on education and "selling". The local belief that technology was limited to large urban areas was changed through extensive discussions and education on ITS, its benefits and the ability to apply the techniques in a flexible, realistic, scaled down and cost-effective manner. With a centerpiece being a proposed traffic management center located in a new intermodal transportation center, ITS elements have been incorporated in every aspect of the plan. Specifics include more responsive traffic monitoring, traffic signals, advanced systems, transit bus location, parking system guidance elements and advanced traveler information systems.

Title of Reference: Intelligent Transportation Systems

Book/Periodical:

Author: (not listed)

Date: 1997
Publisher: TRW, Inc. (Fairfax, VA)
Annotation: This pamphlet gives an overview of the different technologies that TRW, Inc. offers its customers. In doing so, several examples of successful ITS implementation are given as well as descriptions of the strengths of the company.

Title of Reference: Intelligent Transportation Systems Publications

Book/Periodical:

Author: (none listed)

Date: 1997
Publisher: U.S. DOT
Annotation: This catalogue lists publications relating to ITS that have been published by the Federal Transit Administration, the Federal Highway Administration, the Federal Railroad Administration, and the National Highway Traffic Safety Administration.

<u>Title of Reference:</u> Intelligent Transportation Systems: Real World Benefits

Book/Periodical:

Author: Apogee/Hagler Bailly

Date: 1997
Publisher: Apogee Research, Incorporated (Bethesda, MD)
Annotation: The four sections of this report summarize the benefits seen in real-world applications of Intelligent Transportation Systems (ITS) in: metropolitan areas; rural areas; commercial trucking; and intelligent vehicle systems. For the lay reader, this report brings together information on the real-world benefits of ITS in a single source. In general, the benefits of ITS include: enhanced public safety; reduced congestion; improved access to travel and transit information; cost savings to motor carriers, transit operators, toll authorities, and government agencies; and reduced environmental impacts.

<u>Title of Reference:</u> Intelligent Transportation Systems: User Demands and Markets for the Global ITS Industry

Book/Periodical:

Author: (not listed)

Date: 1997
Publisher: SRI Consulting (Menlo Park, CA)
Annotation: This brochure gives an overview of a current research project being performed by SRI Consulting. The study focuses on industry technologies, applications, and commercial development. Their results will be published in four reports: Technology and Application Evaluations; Market Report: ATMS, ETC, PVTMS, and CVO; Driver Information and Vehicle Safety and Control; and Leading Company Activities and Strategies.

<u>Title of Reference:</u> ITS and Rural Transit

Book/Periodical: Presented at the CTAA Expo 97; Ft. Lauderdale, FL

Author: Boenau, Ronald E

Date: 1997
Publisher:
Annotation: This presentation explains the basics of ITS and gives an overview of characteristics of rural transit needs. He then combines both subjects to show how ITS can be effectively implemented in rural areas.

Title of Reference: ITS and Smaller Transit Systems

Book/Periodical:

Author: Winters, Chris

Date: 1996
Publisher: Community Transportation Association of America
Annotation: This short insert provides an introduction for various types of ITS technology that could be used in rural systems. Topics include: GIS, AVL, Mobile Data Systems, Intelligent Traveler Information, and Communications.

Title of Reference: ITS Deployment Guidance for Transit Systems Technical Edition

Book/Periodical:

Author: P.B. Farradyne Inc.

Date: 1997
Publisher: Federal Highway Administration, U.S. DOT
Annotation: This document provides guidance for the transit community on developing and implementing ITS systems and using the National ITS Architecture. The report gives practical assistance based on real-life experiences with transit ITS technologies. The report contains sections on ITS benefits and concerns, the National ITS architecture and how to use it, best practices / lessons learned, how to find out more information about ITS, existing and planned standards, and sample RFPs and specifications.

Title of Reference: IVHS Transit Applications: Rural/Small Urban Areas

Book/Periodical: ASCE Third International Conference on Applications of Highway Administration

Author: Richards, S.H.; Wegman, F.J.; Reddy, P.; Hendrickson, C.T. (Editor); Sinha, K. (Editor)

Date: 1993
Publisher: American Society of Civil Engineers (New York, NY)
Annotation: In an effort to identify potential IVHS (intelligent vehicle highway systems) applications, direct input was sought from public transportation managers. A 'focus' approach was used to encourage objectivity and depth of coverage, and officials representing different public transportation services, including fixed-route bus, paratransit, ridesharing, and rural public transportation, participated in the focus groups. Group participants were asked to judge, in terms of their operations, the effectiveness of each APTS technology relative to its ability to achieve certain specific goals: increasing demand; reducing operating costs; and increasing the comfort and convenience of users. The study findings are presented and discussed.

Title of Reference: Minnesota Guidestar

Book/Periodical: Minnesota DOT Newsletter

Author: (not listed)

Date: 1997
Publisher: Minnesota Department of Transportation
Annotation: This newsletter is an overview of ITS programs across Minnesota. These include conventional urban ITS as well as programs targeting rural areas. One such program is ARTIC, Advanced Rural Transportation Information and Coordination, organizing ITS technology in rural areas in a coordinated communications center.

Title of Reference: Multipurpose Transit Payment Media

Book/Periodical:

Author: Schweiger, Carol; Lott, David; Pierlott, George

Date: 1998
Publisher: Transit Cooperative Research Program, Transportation Research Board
Annotation: Examines the potential for developing multipurpose media linking transit systems fare payment to other payment applications. Examined 30 systems worldwide to understand complex technology integration, costs, benefits, and implementation issues.

Title of Reference: National Architecture Considerations for Rural ATIS

Book/Periodical: Proceedings of the 1995 Annual Meeting of ITS America

Author: Krueger, M.E.; Zarean, M.; Warren, D.

Date: 1995
Publisher: ITS America
Annotation: The Rural Intelligent Transportation System (Rural ITS) will be the greatest challenge for the national ITS architecture program but may at the same time provide its greatest benefits. The purpose of this paper is to discuss major rural considerations that should be addressed by the national architecture program. Most of the background information within this paper was taken from the "State of the Art Technology Report" developed as part of the FHWA's Rural ATIS study.

Title of Reference: Operational Strategies for Rural Transportation

Book/Periodical:

Author: Ride Solution (Palatka, FL)

Date: 1996
Publisher: U.S. DOT
Annotation: This report discusses technology in rural transportation in the context of demand-responsive transit for passengers covered by Medicaid.

Title of Reference: Passenger Counting Technologies and Procedures

Book/Periodical:

Author: Boyle, Daniel K.

Date: 1998
Publisher: Transportation Research Board
Annotation: Summarizes information from selected transit agencies about benefits and problems associated with each passenger counting technology, and provides advice for agencies considering such technologies.

Title of Reference: PC-TRANS: Lending a Helpful Hand

Book/Periodical: ITE Journal

Author: Thor, C.

Date: 1991
Publisher: Institute of Transportation Engineers (Washington, DC)
Annotation: The PC-TRANS Center of the University of Kansas (KU) provides technical support and a forum for the exchange of ideas, information, and experience for transportation professionals. Major areas addressed by the center include highway engineering, regional and rural transportation planning, traffic engineering and safety, and transit operations. Newsletters published by the center, and a software directory, are noted as well as its microcomputer applications services. PC-TRANS is a source for a wide variety of transportation software programs. Its contribution to the educational mission of KU is also noted.

Title of Reference: Planning for the Evaluation of a Mobility Manager

Book/Periodical: Abstracts of the Third World Congress on Intelligent Transport Systems; Orlando, Florida

Author: Harris, M.J.

Date: 1996
Publisher: ITS America
Annotation: The Beaver County Transit Authority (BCTA) is implementing a Mobility Manager Pilot Project. The proposed test site is Beaver County, Pennsylvania, a rural-suburban county in the Pittsburgh metropolitan area. Castle Rock Consultants is to produce an evaluation plan for this project including guidance in the planning, design, and implementation of the Mobility Manager evaluation

Title of Reference: Planning, Implementation and Evaluation of Ominride Demand-Driven Transit Operations: Feeder and Flex-Route Service

Book/Periodical: Transportation Research Record, No. 1557

Author: Farwel, R.G.; Marx, E.

Date: 1996
Publisher: Transportation Research Board; Washington, DC
Annotation: Information about the Potomac and Rappahannock Transportation Commission operational test is presented. The test focuses on service planning for the local flex-route transit services and the flag-stop commuter-rail feeder services, as well as their start-ups. Although the intelligent transportation system (ITS) operational test involves the application of automated vehicle location and real-time order-taking, scheduling, and dispatching software, the planning and start-up operations of the non-ITS-enhanced phase of the flex-route and feeder services are addressed.

Title of Reference: Procuring Paratransit Software - A Management Workshop

Book/Periodical:

Author: KFH Group, Bethesda, MD.

Date: 1996
Publisher:
Annotation: This workshop for rural and paratransit operators is designed to review all of the pertinent issues revolving around the development of specifications, the procurement and on-going implementation activities of paratransit technologies. This course has been conducted at the CTAA Expo, as well as in the states of North Carolina and Texas.

Title of Reference: Providing Information to Rural Transit Passengers

Book/Periodical: Abstracts of the Third World Congress on Intelligent Transport Systems; Orlando, Florida

Author: James, R.D. and Aatique, M.

Date: 1996
Publisher: ITS America
Annotation: Blacksburg Transit is the site of a new operational test beginning in early 1996 to examine new traveler information systems in a rural community. The project will span 18 months until completion. This paper will discuss the design of the passenger information system that is unique for the rural environment and the response of the passengers to the system. The goal of this operational test is to develop a rural transit traveler information system that will maximize user acceptance of transit systems at a reasonable cost to rural transit agencies. As part of the project, 30 buses are being equipped with the necessary Automatic Vehicle Location (AVL) equipment to monitor its position from a central dispatch. A central dispatch will calculate arrival times to the various bus stops and distribute the information to the travelers through various media including the information highway via the Internet, strategically placed kiosks, audiotex telephone access, displays at the stops, and cable TV. The design of these systems vary widely compared to systems used in an urban environment.

Title of Reference: RTAP Survey of Rural Transit Providers

Book/Periodical:

Author: KFH Group; Bethesda, MD

Date: 1997
Publisher: American Public Works Association (Washington, D.C.)
Annotation: This report reviews a wide variety of attributes and rural transit needs through the use of a comprehensive survey. 1,152 surveys were sent with 350 (30 percent) respondents. There is a section on computer/software needs and current levels, giving insights into the computer capabilities of rural operators. The survey results indicated that many rural operators have not even attempted to use computer technology in any form.

<u>Title of Reference:</u> Rural Application of Advanced Traveler Information Systems: Recommended Actions, and Rural Application of Advanced Traveler Information Systems: User Needs and Technology Assessment

Book/Periodical: U. S. DOT Publication No. FHWA-RD-97-042

Author: Moe Zarean, Ph.D., P.E.

Date: 1996 and 1997
Publisher: Federal Highway Administration, U.S. DOT
Annotation: The purpose of this study was to gain a better understanding of the state of the practice of rural advanced public transportation systems (APTS) technologies and to determine where federal resources could be best directed to close the gap between current practice and the state of the art. This report describes the findings and recommendations of the rural public transportation user needs and applications study. The study examined both the opportunities and challenges of planning and deploying APTS technologies in rural and small urban areas. User and operator surveys and site visits were conducted to determine information requirements, interests, and concerns of both operators and passengers of transit systems in rural and small urban areas. The study examined the state-of-the-art and state-of-the-practice for APTS and advanced traveler information systems, as well as application of APTS technologies to improve financial accountability and data verification. Nine rural ITS action concepts are recommended that address user needs along with a work plan for implementing each action. This user needs and applications study was conducted as part of the U.S. DOT's overall Rural Intelligent Transportation Systems Program.

<u>Title of Reference:</u> Rural Applications of Intelligent Transportation Systems

Book/Periodical:

Author: Wallace, C.E.; Kilpatrick, A.K.; Schneider, K.R.

Date: 1996
Publisher: Transportation Research Center, University of Florida (Gainesville, FL)
Annotation: The Intelligent Transportation System (ITS) program in the U.S.A. is understandably directed primarily toward urbanized areas where congestion is highest, yet rural areas account for four times the mileage of highways. Although 60% of total travel is urban, the 40% on rural roads is still a major share of the nation's travel demand and, unfortunately, the percentages of fatal accidents are nearly reversed -- 57% rural. Travelers on rural facilities, whether they be high type, access controlled highways or two lane country roads, have needs in common with urban travelers, but also particular problems that distinguish driving on these facilities from urban travel. This report addresses the rural travel community needs and the potential benefits that ITS can deliver. It compares the ITS User Services Requirements against perceived rural traveler needs. It summarizes the results of several specialty conferences on rural ITS and describes a number of projects in the area. Specific recommendations offer a plan for heightening the awareness of ITS needs in rural areas.

Title of Reference: Rural ITS Preliminary Planning: The Montana Experience

Book/Periodical: ITS America Seventh Annual Meeting Preprint

Author: McGowan, Patrick; Albert, Stephen

Date: 1997
Publisher: ITS America
Annotation: This paper is a product of a research initiative undertaken by the Montana Department of Transportation (MDT) in an effort to assist rural transit operators in assessing the possibilities of ITS implementation. Rural operators are often burdened by having to conduct the research necessary to convince legislators that ITS is indeed a good idea. Recognizing this difficulty, MDT began a two-phase investigative project. This report outline Phase I, a small-scale preliminary planning effort.

Title of Reference: Rural ITS: Innovative Transportation Solutions

Book/Periodical:

Author: (not listed)

Date: (not indicated)
Publisher: Castle Rock/Black & Veatch Consultants
Annotation: This brochure details the Branson (MO) Travel and Recreation Information Program (TRIP) which will make Branson the hub for regional ITS rural and tourism services throughout the Midwest. Components include: interactive information kiosks, Highway Advisory Radio, web-site showing road conditions, congested areas, etc., and message boards that tell of driving conditions, offering alternative routes.

Title of Reference: Rural Public Transportation Technologies: User Needs and Applications

Book/Periodical: U.S. DOT Publication No. FHWA-D-98-146

Author: M. Zarean; B. Buergler; J. Sajovec; Jon Burkhardt; C. L. Schweiger

Date: 1998
Publisher: Federal Highway Administration, U.S. DOT
Annotation: This report presents the findings and recommendations of a national study conducted as part of the U.S. DOT's overall Rural Intelligent Transportation System (ITS) Program. The study examined the opportunities and challenges of planning and deploying advanced public transportation systems (APTS) technologies in rural and small urban areas. Research included user and operator surveys and site visits to determine information requirements, problems, interest, and concerns of both operators and passengers of transit systems in rural and small urban areas. Nine rural ITS action items are recommended to address the identified needs of rural public transportation. The report includes implementation plans for the recommended action items.

Title of Reference: Rural Transit Traveler Developments in ITS

Book/Periodical: ITS America Seventh Annual Meeting Preprint

Author: James, Robert and Siddiqi, Zeeshan

Date: 1997
Publisher: ITS America
Annotation: This report outlines and assesses a test of providing travelers with estimated time of arrival information through the internet, audiotex, kiosk, cable TV, and displays at bus stops. The test was sited in Blacksburg, Virginia because of its high student population and rural density. The initial operation calls for 36 Blacksburg Transit (BT) buses to be fitted with GPS and AVL equipment. It is hoped that by providing ETA information to travelers BT can ease the worry and uncertainty associated with using public transit.

Title of Reference: Rural Transit: An Overview

Book/Periodical: Proceedings from Conference on Rural Intelligent Transportation Systems

Author: James, Robert B. and Islam, Tariqul

Date: 1996
Publisher: ITS America
Annotation: This report summarizes the characteristics, market segments, and needs of rural transit. It then offers suggestions as to how to integrate ITS technology in order to improve transit operations.

Title of Reference: Small Urban and Rural Advanced Public Transportation Systems

Book/Periodical:

Author: Ahmed, T.; Stone, J.; Nalevanko, A.

Date: 1999
Publisher: Federal Transit Administration, U.S. DOT
Annotation: For small urban and rural public transportation operations the challenge is to improve passenger service while maintaining acceptable system productivity and costs. To meet this challenge, transit managers are increasingly turning to Advance Public Transportation Systems (APTS) for support. To apply APTS technology, the managers need product information, case study experiences and peer contacts, guidance on acquiring the APTS products that meet their transit system needs, and the expected payoffs and potential problems that may result. This report provides that information.

Title of Reference: Strategic Plan for ITS Education and Training (Draft)

Book/Periodical:

Author: Strickland, Bo

Date: 1996
Publisher: ITS America
Annotation: This report addresses the need for education about ITS and its functions. It is the product of a workshop held on the subject at which discussion was broken down into seven main groups. Groups focused on: (1) Formal education - precollege through associate degrees; (2) Formal education - baccalaureate and graduate programs; (3) Informal and non - degree education and training; (4) public agencies; (5) Manufacturers and service providers; (6) transportation companies; and (7) students. Recommendations were made accordingly.

Title of Reference: Technology Exchange

Book/Periodical: Newsletter of the Minnesota Technology Transfer Program, Center for Transportation Studies

Author: (not listed)

Date: 1997
Publisher: University of Minnesota
Annotation: This newsletter gives an overview of ITS projects and related events in Minnesota. Article subjects include: pavement technologies, publications, calendar of events, and recent conference proceedings.

Title of Reference: Technology Plan for North Carolina Transit Systems

Book/Periodical:

Author: Institute for Transportation Research and Education, Transit Operations Group

Date: 1999
Publisher: Public Transit Division, North Carolina Department of Transportation
Annotation: This plan discusses the changing goals of transit, including the development of a customer focus, and the manner in which transit technology can support those goals. Includes recommend technologies and action plan for implementation at six different categories of transit systems. These systems are categorized by type (urban and rural), service type (fixed route and paratransit), and size (number of trips).

Title of Reference: Technology in Rural Transportation: "Simple Solutions"

Book/Periodical: TRB Preprint, No. 98-0330

Author: Bland, Clare E.; Deeter, Dean; Pisano, Paul

Date: 1998
Publisher: Transportation Research Board
Annotation: This paper describes the Rural Outreach Program which sought to identify and catalogue various low-tech solutions for rural transportation problems or needs. The research team examined technologies that while not necessarily considered "ITS" are technology-based, effective, practical approaches that could be considered precursors to ITS. Results show such technologies have been implemented across the country and those responsible for their development did not consider them to be ITS. This report indicates that ITS is being implemented on a local level as well as through the "top-down" approach of national programs.

Title of Reference: The Benefits of ITS Technologies for Rural Transit

Book/Periodical: Proceedings from Conference on Rural Intelligent Transportation Systems

Author: Casey, Robert F.

Date: 1996
Publisher: ITS America
Annotation: This report places rural areas into certain categories based on characteristics such as growth rate and population density. The author also evaluates various types of rural ITS technology as to their suitability in each area type. This is followed by an overview of benefits of each type of technology and several illustrative case studies.

Title of Reference: The Implementation of ARTIC: One Step at a Time

Book/Periodical: Paper presented at 13th National Conference on Rural Public and Intercity Bus Transportation

Author: Maddern, Richard and Kern, Joseph

Date: 1997
Publisher: Transportation Research Board
Annotation: The Advanced Rural Transportation Information and Coordination (ARTIC) Operational Test was designed to test and evaluate the effectiveness of intelligent transportation technology in rural environment. The principal goal is to streamline equipment, personnel, and facilities needs in order to provide better service at a lower cost. This will be accomplished through the use of ITS. The main site of the new technology is the innovative communications center that has new dispatching software, networked workstations for dispatchers, a new radio system and AVL system. The project has been successful because of a multiple agency partnership among the Minnesota Department of Transportation, the Minnesota State Patrol, Arrowhead Transit, and the City of Virginia.

Title of Reference: The National ITS Program: Where We've Been and Where We're Going

Book/Periodical: Public Roads

Author: Johnson, C.M.

Date: 1997
Publisher: Federal Highway Administration, U.S. DOT
Annotation: Since 1991, the National Intelligent Transportation Systems (ITS) Program has pursued research, technology development, and field testing and has promoted deployment of first-generation ITS applications. The program has demonstrated that the ITS concept, even at this early stage, is technically viable, highly cost-effective, and increasingly accepted as an essential component of a modern surface transportation system. To realize the full long-term potential of ITS, however, an information and communication infrastructure is necessary to ensure that ITS services are integrated, intermodal, and interoperable. Although the full potential of ITS has yet to be realized, enough has been learned in the past 5 years to verify the wisdom of forging ahead, nurturing the National ITS Program, and allowing it to fulfill the Intermodal Surface Transportation Efficiency Act's promise of a safer, more efficient, and less costly intermodal transportation system.

Title of Reference: TRANSCAL: A Rural/Urban Traveler Information System

Book/Periodical: Proceedings of the 1996 Annual Meeting of ITS America

Author: Batha, T.

Date: 1996
Publisher: ITS America
Annotation: Emerging capabilities in computing, communications, and consumer electronics are joining forces to improve the quality of traveler information. The TRW TransCal Field Operational Test (FOT) will ultimately result in reduced travel time, decreased traffic congestion, and will improve safety and security in both rural and urban areas. TRW's TransCal test addresses two primary user needs: (1) en route advisory and traveler information services; and (2) emergency notification and personal security. TRW's TransCal partnership will also examine the public and private relationships necessary to move tested applications to full-scale deployment. The TransCal test will implement a comprehensive Inter-regional Traveler Information System (IRTIS) that integrates road, traffic, transit, weather, and value-added traveler services information from sources covering the entire geographic region between San Francisco and the Tahoe/Reno-Sparks area. Building on emerging Intelligent Transportation System (ITS) standards, the information system will disseminate information to and from travelers via telephone, personal digital assistants, in-vehicle navigation and display devices, and interactive kiosks, as well as through traditional broadcast media. Wireline and cellular telephone, and wireless FM subcarrier networks will be used to transmit information. The information system will be integrated with a satellite-based mayday system to provide emergency notification with low-cost coverage at any location. Mayday can be automatically or manually triggered to alert the information system about emergencies.

Title of Reference: Transit Market Segments in Rural America

Book/Periodical: Report

Author: Jon E. Burkhardt, James L. Hedrick, Adam T. McGavock

Date: 1997
Publisher: Volpe Transportation Center and Federal Transit Administration, U. S. DOT
Annotation: Considered a follow-up study to ITS Applications for Community Transportation which was the initial FTA research in rural transit markets that identified five markets based on growth, size and proximity to urban areas. Transit Market Segments in Rural America added two market segments based on poverty rates.

<u>itle of Reference:</u> Transportation and Rural Revitalization

Book/Periodical:

Author: Carolyn Jeskey

Date: 1995
Publisher: Community Transportation Association of America (Washington DC)
Annotation: This report describes the activities of USDA's Rural Passenger Transportation Technical Assistance Program(RPTTAP). It includes profiles of five projects completed with assistance from the RPTTAP as well as two projects that were underway at the time. Transit operators profiled include: Advance Transit in Lebannon New Hampshire; Treasure Valley Transit in Canyon County, Idaho; STAR in Sweetwater County, Wyoming; COLTS in Lee County, North Carolina; and CARTS in Austin, Texas.

Appendix D. Decision Tree Diagram

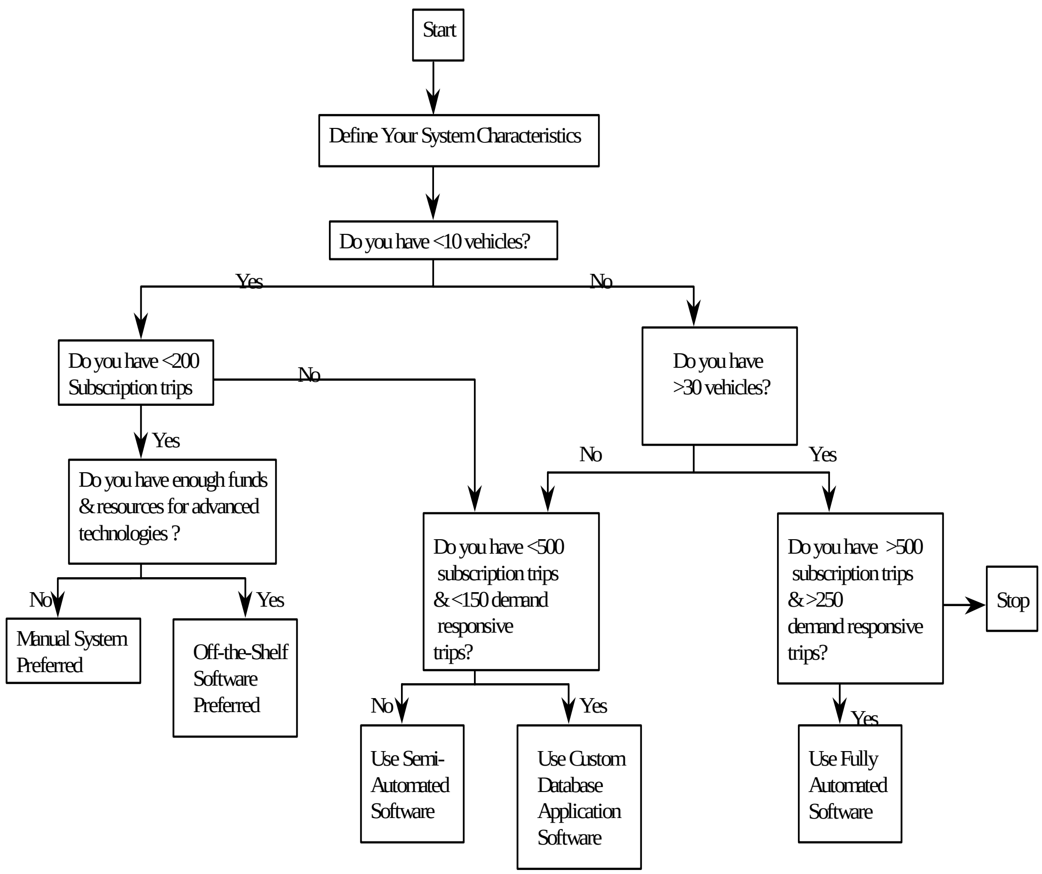


Figure 4.5.3: Decision Tree for the Detailed Assessment Approach

Appendix E.

North Carolina Public Transportation Systems Technology Plan

Category 1 – Small and Medium Public Transportation Systems

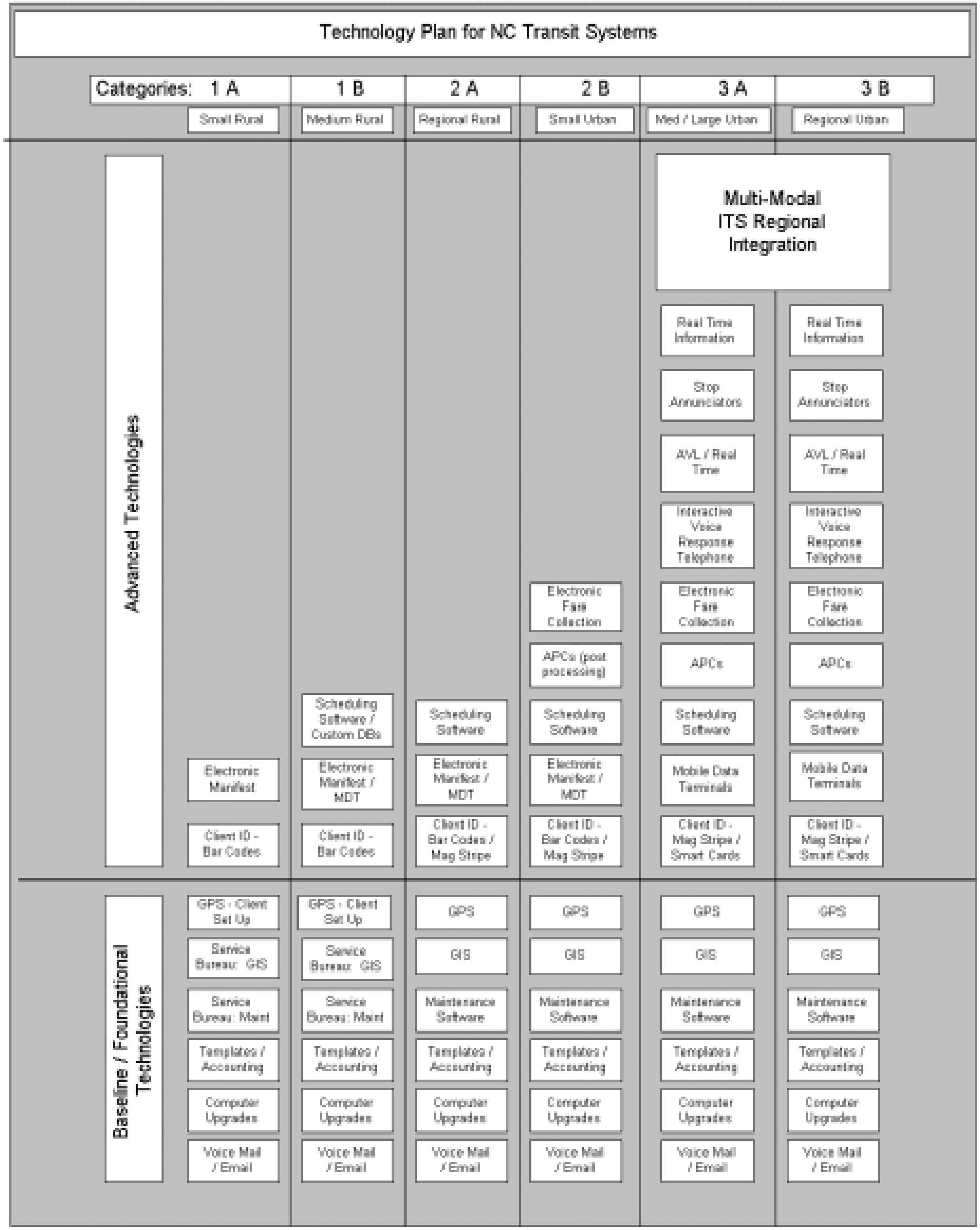
Characteristics	Category 1 A: SMALL RURAL PUBLIC Transportation Systems	Category 1 B: Medium Rural Public Transportation Systems
Trips / day	< 100	< 250
% Subscription Trips	> 80	> 75
Agency Contracts	< 10	11 – 19
Growth Potential	Slow or None	Average
Regional	No Plan	No Plan

Category 2 – Large Regional Rural and Small Urban Public Transportation Systems

Characteristics	Category 2 A: Large Regional Rural Public Transportation Systems	Category 2 B: Small Urban Public Transportation Systems
PARATRANSIT		
Trips / day	< 600	< 100
% Subscription Trips	> 75	> 75
Agency Contracts	> 15	Maybe
Growth Potential	Average to High	Average
Regional	Entity or Plan	No Plan
FIXED ROUTE		
Trips / day		< 2000
Peak Vehicles		< 14
Cash fares / day		< $500
Ridership Trends		Flat

Category 3 – Medium to Large or Regional Urban Public Transportation Systems

Characteristics	Category 3 A: Medium to Large Urban Public Transportation Systems	Category 3 B: Regional Public Transportation Systems
PARATRANSIT		
Trips / day	> 200	
% Subscription Trips	> 75	
Agency Contracts	Maybe	Maybe / ADA Compliance
Growth Potential	Average to High	Average
Regional	Maybe Plan	Plan
FIXED ROUTE		
Trips / Day	> 3000	> 2000
Peak Vehicles	> 14	> 10
Cash fares / day	> $1000	N / A
Ridership Trends	Flat or Falling	Flat


Technology Plan for NC Transit Systems
Categories: 1 A
1 B
2 A
2 B
3 A
3 B
Small Rural
Medium Rural
Regional Rural
Small Urban
Med / Large Urban
Regional Urban
Advanced Technologies
Multi-Modal ITS Regional Integration
Real Time Information
Stop Annunciators
AVL / Real Time
Interactive Voice Response Telephone
Electronic Fare Collection
APCs (post processing)
APCs
Scheduling Software / Custom DBs
Scheduling Software
Electronic Manifest
Electronic Manifest / MDT
Mobile Data Terminals
Client ID - Bar Codes
Client ID - Bar Codes / Mag Stripe
Client ID - Mag Stripe / Smart Cards
Baseline / Foundational Technologies
GPS - Client Set Up
GPS
Service Bureau: GIS
GIS
Service Bureau: Maint
Maintenance Software
Templates / Accounting
Computer Upgrades
Voice Mail / Email

APPENDIX F

Case Study Summaries

Detailed Case Studies

Case Study Report Summary #1: Aiken Area Council on Aging

I. AGENCY

Aiken Area Council on Aging
159 Morgan Street
Aiken, South Carolina

Beth Hollingsworth, Assistant Executive Director
(803) 648-5447
(803) 649-1005 (fax)
Email: aacoa@ddminc.net

II. SUMMARY STATEMENT/HIGHLIGHTS

The Aiken Area Council on Aging provides fixed-route and demand-responsive transit services to senior citizens, and to the general public and several human service agencies by contract. Although the transit operations are small, there is a great need to efficiently collect trip information from the vehicles in order to produce the many billing and grant reports required by their funding sources. The Area Council on Aging successfully met this need by installing an innovative, inexpensive software and an in-vehicle bar code reader system. The system, called AIM Transport, facilitates reservations, generates vehicle schedules, and automatically downloads critical trip information that is recorded by the in-vehicle bar code readers and integrated odometer reader. As a result, the Area Council on Aging achieved its principal goal of reducing the time required to enter trip data into a computer database and generate accurate reports.

As well as being inexpensive compared to DRT software, AIM Transport also provided a fairly error-free implementation. This stability is probably owed to the maturity and stability of the software's parent product, which is a case management software for senior citizen programs. However, this origin from a non-transit technology product may create some barriers as the Area Council on Aging further develops their technology program. AIM Transport does not easily integrate with advanced transit technology products such as GIS and AVL, which are in the long-term technology plan of the Council.

III. BACKGROUND

The Aiken Area Council on Aging is a community transportation operator that consolidates the urban, ADA (Americans with Disabilities Act), senior citizen, Medicaid, welfare-to-work, and rural general public transportation needs into a single service operator. Principally, the Council is the administrator of federal Title III funding in a six county region of South Carolina that lies along the northeast border of Georgia. Title III provides funding for senior citizen nutrition, care management and transportation programs. The Aiken Regional Transit System contracts with the Council to provide urban transportation services in Aiken County, which is the largest county of the Council's six county region. The largest city in this county is Aiken; with an expanding population of approximately 25,000 that is chiefly bolstered by the migration of retirees to the region. Other human service agencies also contract with the Council for client transportation.

The Council on Aging provides approximately 23,000 fixed-route trips annually, plus 8,000 subscription and 5,000 demand-responsive paratransit trips. The majority of the subscription trips are for Title III congregate meal programs, while Medicaid and other types of Title III trips comprise the majority of the demand-responsive trips. The demand for both fixed-route and paratransit service is quickly growing. Four lift-equipped buses and 16 lift-equipped vans provide these services.

In addition to the general administrative staff of the Council on Aging, the Council employs:

- Transportation director;
- Transportation coordinator;
- Scheduler;
- Two dispatchers;
- 12 drivers; and,
- Administrative assistant.

Given the consolidation of several urban and human service transportation services, there is a heavy administrative burden of producing driver manifests, collecting accurate trip data, and generating billing information for the various contracting agencies and funding sources. Several years ago, the Council used hand-written driver manifests, and calculated billing using adding machines. They eventually purchased a network of personal computers and suite of office automation software, and developed spreadsheets and databases to track trips and bill agencies and funding programs. Also, the Council used AIM software, a Windows® based client database, tracking and case management system with pre-formatted activity reports and bar coded data entry. AIM is guaranteed to meet Title III reporting requirements.

However, administrative staff continued to devote much time to transferring trip data to the billing system by data entry, reconciling inaccurate and missing trip data, taking trip requests, and generating driver manifests. Drivers still were distracted from driving and safety duties by the pen-and-paper trip recording system. Furthermore, the Council could not transfer the spreadsheet and database data to the various proprietary client information systems, including the AIM (Advance Information System) that the Council was already using to track Title III client cases; Title III service is their largest paratransit group.

IV. GOALS AND OBJECTIVES

The technology installation had one simple goal—to eliminate an administrative position. The objectives underpinning this goal include:

- Ability to share data with existing AIM information system.
- Provide more accurate trip data.
- Save drivers' time and permit driver to devote attention to passenger safety.
- Reduce time needed to generate agency billing.
- Automatically collect operations data that can be used for performance evaluation.

V. NARRATIVE DESCRIPTION

The Aiken Area Council on Aging issued an RFP (Request for Proposal) for a transportation module to assist reservations, automatically generate driver manifests, easily gather trip data from vehicles, easily generate billing reports, and automatically download the data into the existing AIM system. Although the RFP was a competitive procurement, the logical requirement to automatically integrate with the existing AIM system provided a unique advantage to the Saber Corporation, the developer and marketer of AIM. The Council selected AIM Transport, the transportation module of AIM, and an integrated in-vehicle hardware system.

AIM Transport uses an electronic odometer and portable bar code reader (similar to handheld units used in retail inventory) to record passenger miles. The driver scans a passenger's bar coded ID on the manifest when the passenger boards and disembarks the vehicle, or to indicate no-show trips, deadhead miles, etc. The electronic odometer records the beginning and ending mileage for the passenger into the scanner. When the vehicle returns to the base station and the reader data is downloaded to the computer, the mileage traveled, vehicle identification, time, date, funding source and other needed data are recorded in the client's service file, and made available for accurate, easy reporting. The Vehicle Assignment function uses quick query and click-n-drop features to speed up the trip reservation function, and the driver route manifest can provide fare and special pick-up instructions, as well as the bar coded client and activity (i.e., type of trip or service) identifications. Users easily modify the various databases, and remote users can download data via the Internet or other telecommunication protocol.

The AIM Transport system cost $30,000, including installation, software, hardware, training, and data conversion. The Area Council has scanners for fifteen vehicles. Some of these costs can be broken out to:

- $1,300 base software, plus $600 per seat (i.e., computer);
- $700 per portable bar code scanner/computer (i.e., per vehicle)—the PT2000 model is available from several suppliers;
- $350 per electronic odometer reader (i.e., per vehicle)—only available from Saber Corporation.

Both AIM and AIM Transport, and the connected technologies such as bar coding are mature, proven products. As a result, the system has performed without major problems, and installation and training required a total of only four days. Furthermore, the system has drastically reduced the time to perform the various data collection and report writing functions. For example, data entry of vehicle trip data previously required one full-time staff person, but the scanner download of the same data requires only two hours per day. Likewise, the requirement to reconcile data is greatly reduced. The Council has assigned additional duties, such as driver supervision, to the administrative personnel rather than reducing staff levels. The personnel have welcomed their more enriched job duties.

The Council ensured problem-free installation and use with a few good practices:

- They trained drivers and staff, and made sure these employees understood the need for the system and how to use the various features.
- They operated the new and old systems in parallel and compared outputs. They waited until they were absolutely confident that the AIM Transport system was performing properly before discontinuing use of the old system.

AIM Transport provides the opportunity to integrate some additional technologies for advancing the Council's evaluation capabilities. The system provides plentiful, accurate trip data that can be easily related to the client case management data in the AIM system. The Council has not taken advantage of this large relational database, yet. However, they plan to purchase a GIS system to integrate AIM Transport, client and existing GIS base map data to relate human service transit demand with key demographic indicators. A more long-term system concept includes AVL to increase on-time trip performance and smart cards to further integrate the transit demands of human service clients.

One problem with the AIM Transport system involved an oversight in the RFP and contract. The Council only required data conversion of the Title III client database. Subsequently, ADA, general public, Medicaid and other human service client information required a few weeks of staff time over a one year period to complete the data entry of these passengers.

The Council may experience a design limitation of AIM Transport. The software is a module of AIM, and this parent software focuses on client case management features instead of transportation capabilities. As a result, the AIM Transport does not easily integrate with GIS, AVL, and MDT systems. The Area Council will have to create a system to import, display and analyze the data in a GIS format in order to achieve their mid-term technology plan, and will face similar integration issues with the AVL and smart cards components of their long-term system concept.

The South Carolina Department of Transportation (SCDOT) provided the funding for the AIM Transport system. However, since the time of that grant, the SCDOT has embarked on developing a statewide transit database management system, making funding for more stand-alone systems unlikely.

VI. DATA AND STATISTICS

The system has drastically reduced the time to perform the various data collection and report writing functions. Data entry of vehicle trip data previously required one full-time staff person, but the scanner download of the same data requires only two hours per day. Time required to reconcile trip data has also been reduced.

VII. EVALUATION AND TRANSFERABILITY

The AIM Transport system is an example of an inexpensive, low technology solution. The Windows® based parent software, AIM, and the bar code technology are proven products and technology. This maturity helps to control costs, and reduce the likelihood of installation and usage problems. The total system cost including training, $30,000, is inexpensive compared to other systems that automatically collect vehicle and trip data, and additional vehicles can be added to the system for only $1,050 each. The installation and initiation was virtually problem-free.

The Aiken Area Council on Aging's choice of AIM Transport appears indicative of the transportation needs of many small community transportation systems. Given the Council's relatively low annual service levels (23,000 fixed-route, 8,000 subscription and 5,000 demand-responsive trips), they did not indicate a great need to support call-taking, dispatching, scheduling and routing functions. The need to support these functions is often assumed for all transit systems, but service levels in small systems do not require such support. On the other hand, the Council had a great need to support trip data collection, billing and reporting given the large mix of different human service agencies to which they provide service. As a result, they selected AIM Transport, which is based on a client service and case management software, instead of DRT software that has a comparative advantage in call-taking, scheduling, and other transit-specific functions. Agencies with similar transit service levels and existing human service case management systems would benefit from using the AIM system.

However, systems that expect great growth in transit service levels and expect to make use of advanced technology systems may find the AIM system limiting. The AIM system focus on client management means that some transit needs, such as GIS, are not easily met by the AIM system. In this case, the transit system must develop and maintain a GIS interface. Furthermore, if the transit system wants to install AVL or MDTs as part of a long-term technology strategy for a growing transit system, the AIM Transport currently has no interface to those types of technology. There seems to be a need for an inexpensive, low technology software/hardware system that meets the less complex needs of small community transportation systems, and permits for possible expansion to advanced technologies. These less complex needs are to: assist call-taking; print manifests; automatically collect trip data; capably generate billing and funding reports; and, provide options to other features such as GIS.

Case Study Report Summary #2: Arrowhead Transit

I. AGENCY

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II. SUMMARY STATEMENT/HIGHLIGHTS

Arrowhead Transit, in concert with the Minnesota Department of Transportation (MNDOT), implemented a project that included a scheduling and dispatch system, a GPS-based AVL system, mobile data terminals (MDTs) and the communications backbone required to handle the messaging to and from their vehicles. This was part of a project that also involved equipping MNDOT highway maintenance vehicles and state police vehicles with the AVL system and establishing a joint dispatch center for the highway maintenance and state police. Arrowhead Transit's dispatch function was also intended to be co-located with the joint highway and police dispatch center with the transit system vehicles helping to serve as additional eyes and ears to monitor traffic, weather, and highway conditions.

For Arrowhead Transit, the project objectives included improving the vehicle productivity of the system through various operational improvements and reducing administrative expenses by enabling them to consolidate their dispatching at one location and by improving the billing and record-keeping functions.

The transit applications of this project failed during the acceptance testing phase and did not proceed forward. The project failed for two reasons. The satellite system used for communication between vehicles and the base station took several minutes to deliver trip information to the vehicles. In addition, the software that interfaced the scheduling software and communication system often sent trip information to the wrong vehicle.

III. Background

Arrowhead Transit serves a very large geographic area covering eight counties in northeastern Minnesota. Its service area covers approximately 21,000 square miles, which is equal to about one-half the size of the State of Ohio. The area it serves is largely rural and very sparsely populated with a number of small cities plus the City of Duluth. Given the size of the service area and its geographic characteristics, radio communication has been a problem. The central dispatch office frequently is unable to communicate with vehicles in some parts of the area. Cellular phones are frequently used as a backup to the radio system. Also due to the size of the area, there are multiple operating bases and two dispatch centers. Vehicles operate out of five operating bases and some drivers take their vehicles home with them at night due to the distances involved.

The multiple dispatch centers plus the lack of consistent radio communication creates inefficiencies in both the operation of the system and in its administration. The communications problems also pose safety concerns particularly in the winter months and in the more remote areas of the region.

IV. Goals and Objectives

Working with MNDOT, Arrowhead Transit began efforts to implement an improved communications and dispatch system. Under the project, Arrowhead Transit's dispatch functions were to be consolidated in one location and co-located with the dispatch functions of the MNDOT district highway maintenance operation and the Minnesota State Police. Under this arrangement, the dispatch functions of the police and highway maintenance were to be combined while the transit dispatch would be located in the same facility.

From the transit perspective, the project was designed to provide Arrowhead with Mobile Data Terminals (MDTs), scheduling and dispatching software, more reliable communications between the dispatch center and the vehicles, and a GPS-based AVL system. By providing the improved communications and the real-time vehicle location information, it was hoped that Arrowhead would achieve improved safety and be able to offer improved service to the public including a greater number of same-day trips. Combined, the various improvements were designed to also increase the operational efficiency of the service and achieve higher levels of productivity. An additional objective was to reduce administrative costs by consolidating the dispatch function in one location and by reducing the paperwork involved in translating the driver trip manifests into billing records.

From the perspective of MNDOT and the State Police, the consolidated dispatch would achieve improved efficiency and reduced costs. The highway maintenance vehicles and the police vehicles were all to be equipped with GPS and tied into a GIS-based mapping system at the dispatch center. The AVL function would lead to improved safety and increase the efficiency of the highway maintenance function, particularly through being able to track the progress of salt trucks during the winter months. All of the AVL-equipped vehicles, including those of the transit system, would be able to provide real-time information on traffic conditions in the region. Additionally, the improved communications would provide for additional eyes and ears out on the road to report back on weather conditions, to check on emergencies, and to relay information about road conditions (e.g., the need for salting)

V. Narrative Description

The transit applications of the project have not been successful. Serious problems, primarily with the software controlling communications to and from the MDTs, were encountered and the transit application of the project was terminated. As of December 1999, all project-related equipment had been removed from the Arrowhead Transit vehicles, including the MDTs and the AVL system. As of the date of the site visit in December 1999, there was a strong possibility that the problems associated with the project would end up in litigation. As a result, the Attorney General's office of the State of Minnesota has instructed project participants to limit their comments relative to the specifics of the problems encountered. This somewhat limits the ability to obtain a good reading into the details of the problems. The non-transit portion of the project, which included AVL, but did not include MDTs, has worked well and is continuing.

MNDOT continues to have faith in the concept behind the project and is working towards the establishment of additional joint dispatch centers throughout the state. Their intention is to implement these Transportation Operations and Communications Centers (TOCC) in each of their districts. Each district would include joint highway maintenance and police dispatching and, where appropriate, local transit dispatching. In some cases, the transit system involvement may include a "virtual presence" rather than the physical presence that was designed into the system in the Arrowhead area.

In the case of the Arrowhead project, MNDOT developed the funding and management plans for the dispatch center and the ITS technology. The majority of the funding came from U.S. DOT ITS demonstration funding, with the remainder coming from MNDOT. The department's general policy for ITS development is for the funding to be 80 percent federal and 20 percent local (including state funding where the state is a direct project participant.) For the Arrowhead project, the state picked up the entire local share due to the developmental nature of the project. Their intent is for the state to reduce its contribution, and require local governments to increase their share of funding once the technologies mature and prove themselves.

While the state provided the primary impetus for the project, Arrowhead Transit was an enthusiastic and willing participant due to the needs and problems cited. The state and the transit system worked together closely to jointly design the system and ensure that the elements needed to respond to Arrowhead's requirements were included in the project's specifications. The intent was for this to serve as a model for the TOCC concept throughout the state.

The ITS application for Arrowhead Transit was obtained under a single procurement that included the GPS-based AVL system, MDTs, the communications link for the MDTs, the scheduling and dispatching software, and the software to manage the communications. Additionally, in conjunction with the establishment of the joint dispatching function with MNDOT and the State Police, a base station was set up in the local MNDOT facility in Virginia, MN.

Upon installation of the hardware and software, training of Arrowhead Transit staff was completed. This was followed by acceptance testing of the system. During the testing, dispatching continued to be done out of the main Arrowhead Transit base in Gilbert. Serious problems were encountered relatively early in the testing phase. The most serious problems related to delays in the communication of messages to and from the MDTs and in the software controlling the MDT messaging. The communications link relied upon a satellite communications system utilizing high earth orbit satellites. It was anticipated that this system would encounter a two to three minute delay in messages getting from the dispatch base to the vehicles. This was deemed to be acceptable. However, during the testing, delays of from five to seven minutes were encountered. This caused problems when dispatch communicated new orders or changes to the drivers, since a vehicle could be headed in the wrong direction and could travel quite a distance during the communications delay. They had to continue to rely on voice communications using the existing radio system. Since unreliability of the radio system was one of the problems that the new system was designed to overcome, this was not acceptable.

An even more serious problem was related to the software controlling the communication to the MDTs. Among the problems was the fact that messages were frequently sent to the wrong vehicle. Dispatch would send messages to vehicle A and vehicle B with vehicle A getting the message intended for vehicle B and vice versa.

After repeated efforts to resolve the software and communications problems were unsuccessful, the decision was made not to accept the system. As a result, all components of the system were removed from the vehicles and from the Arrowhead Transit dispatch center. The base station at the MNDOT facility in Virginia is still in place, but it has never been used. Arrowhead Transit has reverted back to its old systems for taking orders, dispatching vehicles, and communicating between the base stations and the vehicles. Plans to consolidate the dispatch function at one site are also on hold. The joint dispatching between MNDOT and the State Police continues in operation and has been deemed to be a success by both the police and the transportation department. This system did not utilize the MDT technology.

VI. Data and Statistics

Because the system did not proceed beyond the testing phase, there are no before and after data to be analyzed or reported. System productivity has increased slightly due to ridership growth, but not to the level that was anticipated to occur as a result of the project. Likewise, the reductions in administrative expense and effort that were to be achieved through consolidating the dispatching function and automating the billing process have also not been realized.

VII. Evaluation

Perhaps the principal finding to be made from this project is a reminder of the risks involved with any relatively new technology or combination of technologies. On the surface, it would appear that things were done as they should be on this project, yet the result was a failure. The project had been on the drawing boards for quite some time and it had garnered the enthusiastic support of the major parties involved, including a buy-in on the part of the staff of the transit system that would be working with the technology on a day-to-day basis. There were also no obvious shortcomings in the project design or concept and the development of specifications and the bid documents was done in a thorough and professional manner.

Local staff were somewhat circumspect in commenting upon the particulars of the problems encountered due to the possibility of upcoming legal action. However, one suggestion involved the importance of having a very clearly stated and defined set of acceptance criteria to be utilized in evaluating the results of the formal acceptance testing for any technology or system that is being implemented.

Another lesson from this project hearkens back to the old adage about a chain only being as strong as its weakest link. A critical characteristic of this project was the need to piece together a number of separate technologies and have them to work together and communicate among each other. Any one piece of the technology package or any one part of the software tying them together was capable of bringing the whole project down. Although it appeared that each individual portion of the technology had been proven in past applications, this project brought together a combination of technologies, including software that had not previously been packaged in a similar manner. When one element failed, primarily the communications software, the entire project was jeopardized.

The procurement for the Arrowhead project was done as a single joint procurement with all elements of the projects being obtained together under one basic contract. In contrast, other projects of a similar nature have been procured on a piecemeal basis with each of the major components being purchased separately but with a single entity then being responsible for integrating all of the individual pieces. Arguments in support of either approach could probably be made. However, in the case of Arrowhead Transit, the fact that everything was procured under a single contract apparently prevented them from being able to accept the elements that worked and rebid the elements that did not work. As a result, the entire transit portion of the project ended up being terminated.

VIII. Transferability

The basic concepts behind the Arrowhead project appear to be sound and are in use elsewhere. MNDOT remains committed to the concept of the TOCCs and the involvement of local transit systems in these centers to one degree or another. Other sites considering a similar implementation need to pay particular attention to how each of the separate elements of the project work in concert with each other and recognize the critical nature of the software that accomplishes this.

The communications backbone and the software supporting it are critical design elements and can be particularly site-sensitive. In the case of Arrowhead Transit, their communications choices were somewhat limited by the characteristics of the area in which they operate. This eliminated some communications choices that have proven to be very successful elsewhere. Among these are use of the 800-900 MHz radio bands and the use of cellular digital packet distribution (CDPD) technology. The basic infrastructure for these technologies was not deemed to be adequately available in the Arrowhead area to support their cost-effective use. As a result, the high earth orbit satellite communications system was selected. This proved to be inadequate in terms of the level of service provided and was, along with the software problems, a contributing factor to the failure of the project. Other systems considering the implementation of MDTs need to give very close attention to the choices that they have for the communications backbone and determine whether or not their available choices can adequately meet their needs and support a successful implementation.

Another issue for others to consider is to be prepared to deal with failure. The possibility of failure does exist, particularly when dealing with things such as new technology applications. The staff at Arrowhead Transit thoroughly bought into the ideas and concepts behind the project, seeing the need for the project and understanding how the intended results would improve the operations of the system. During the training and testing periods, staff invested a considerable amount of time and effort into the project, doing their part to make it succeed. There was considerable disappointment when the project failed. Existing management at Arrowhead Transit believes that the staff remains committed to the concepts embodied in the project, but is a little bit leery of implementing a new project out of concern that the level of involvement and sense of "ownership" could be lacking due to the past negative experience.

Case Study Report Summary #3: Cape Cod Regional Transit Authority

I. Agency/Organization

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II. Summary Statement/Highlights

The Cape Cod Regional Transit Authority developed the organization and is installing the technology infrastructure to complete a truly multimodal, regional advanced public transportation system. In 1997, CCRTA completed an FTA-sponsored GIS mapping project that adjusted fixed-routes to allow more paratransit clients to use the fixed-route system. They expanded their vision to develop an integrated communication, computer software and smart card technology system that would provide the historical and real-time data to continue improving the various transit services and modes, and increase vehicle efficiency and timeliness, provide real-time customer information, and impact travel behavior to reduce traffic congestion and pollution.

After testing AVL in 20 vehicles in Phase I, CCRTA is implementing Phase II of the project. They are installing MDTs and AVL in all 90 vehicles of their fixed-route and paratransit fleet, adding digital radio channels and system by installing two new radio towers, and upgrading their custom-designed paratransit management software to operate in the Windows® environment on an NT server. An open system architecture and future expansion capabilities are key system requirements that will allow easier integration of the CCRTA system with intercity bus carriers, ferry service, taxicabs, the adjacent transit system, GATRA, and retailers and banks. The MDTs can use magnetic stripe and smart cards, and communicate via radio, CDPD—Cellular Digital Packet Data, and several other protocols. This multi-faceted integration with other systems will produce a broad range of impacts.

The broad range of project impacts has helped CCRTA to fund the estimated $1.5 million total project cost. FTA Section 26 demonstration funding totaled $200,000, and the MPO (Metropolitan Planning Organization) “flexed” approximately $700,000 of CMAQ (Congestion Management and Air Quality) funding to the project, while a state capital program, Access to Jobs and the Rural Intercity program, intercity bus service [Section 18(i)], have also contributed.

Several strategic events have enabled CCRTA to envision, manage and fund this large undertaking. A public-private partnership including CCRTA, GATRA and the GeoGraphics Laboratory at Bridgewater State College, among others, has expanded funding opportunities, lowered the cost of group procurements and provided negotiating leverage with the technology industry. Furthermore, the respected experience of the project manager, assistant administrator and operations manager have help to attract the funding and support needed from a variety of local, state and federal sources.

III. Background

CCRTA provides regional demand responsive, human service, fixed-route, and community bus transportation services (including summer trolleys). There are 90 vehicles delivering these services, including buses, vans, and trolley buses. The system connects with other transit modes including inter-city bus, inter-city rail, ferry, local town mini-bus, and taxicab transportation services. The service area population peaks around 600,000 during the summer.

CCRTA uses a DOS-based reservation/scheduling software that was developed for their system. This customized software, which CCRTA has used for almost two decades, functions similar to a "slot scheduler"; it offers three to four scheduling options to the reservationist and produces a vehicle schedule based on the reservationist's decision. Using this computer-assisted manual scheduling system, CCRTA has attained a paratransit performance of four trips per hour. They believe that it would be difficult to significantly improve this performance using automated scheduling technology, and therefore have focused on moving paratransit trips to the fixed-route service.

In 1996, CCRTA worked with the director of the Moakley Center GeoGraphics Lab at Bridgewater State College, to successfully develop a GIS mapping system that identified paratransit clients and demand, and adjust fixed-route service to attract clients away from the relatively expensive paratransit service. In 1997, the FTA wanted to fund demonstrations of advanced technology in rural transit using Section 26 funding. CCRTA was subsequently awarded $200,000 based on the success of the GIS project, the experience of the CCRTA leadership, and the FTA desire to include a tourist area in the demonstration projects. CCRTA possessed service characteristics that would benefit from AVL, MDT and Smart Card technologies, including: the need to coordinate intermodal connections between the fixed-route, paratransit, intercity buses, ferry, and train; and long headways (time between stop pick ups) among these services. Furthermore, citizens and tourists in the service area are considered relatively savvy about technology and therefore more likely to embrace it. In fact, part of the county is now referred to as the "silicon sandbar."

IV. Goals and Objectives

The primary goals of CCRTA in implementing technology systems are to alleviate traffic congestion and pollution in the Cape Cod area, especially during the summer tourist season, and to provide reliable access to jobs for year-round residents. A key component is to integrate the various transportation modes, including fixed-route, demand-responsive, and intercity buses, through a single, convenient payments system, and on-time modal connections. Timely vehicle location information, and improved operations based on the availability of historical and real time operations data should attract more customers. Data is to be integrated and shared with land development and highway systems, as well.

V. Narrative Description

In order to achieve these goals, CCRTA is installing and integrating a broad range of advanced transit technology systems. The principal systems include:

- Powerful Local Area Network (LAN), additional digital radio channels and Cape-wide radio coverage as a firm infrastructure base—completed.
- A Geographic Information System (GIS) capable of mapping service demand—completed.
- A customized DRT software—completed.
- Automatic Vehicle Location capabilities based on a Global Positioning Satellite (GPS) system—the 20-vehicle Phase I test is complete, and installation on all 90 vehicles in the fleet is scheduled for completion in June 2000.
- Mobile Data Computers (MDCs) capable of collecting extensive on-board vehicle data, downloading schedules, using two-way messaging, employing emergency alarms, integrating with AVL, and using various radio and cellular communications, and smart card technologies—in progress.
- Advanced Travel Planning (ATP) available via the Internet that includes customer accessible vehicle location information—continued development.
- Electronic Payment Systems (EPS) integrated with other travel modes, retailers and banks—planned.

An open architecture and the capability to integrate with many device standards are the basic requirements that will allow the CCRTA system to integrate with the adjacent transit provider, GATRA, private transit services, banks and retailers.

The CCRTA system has overcome several problems. In Phase I, CCRTA tested AVL on 20 vehicles. The contractor did not have an existing product, and therefore had to completely design and develop the system. As a result, CCRTA was to bear the full cost of product development, which included cost overruns, and the software suffered proprietary incompatibility with other systems. CCRTA was able to acquire "flexed" CMAQ funding from the MPO to continue the project. The project team and consortium rebid Phase II, i.e., AVL and MDTs in all vehicles, to ensure greater inter-system capabilities and look at proven, cost-effective, integrated products. The CCRTA procurement experience showed that products for the taxicab industry appeared to best meet their needs. These products proved to be more mature and stable, and lower-cost.

The AVL data transfer, taking place every 20 seconds for each vehicle, increased the digital bandwidth requirements for CCRTA. Existing communications networks, such as cellular telephone systems, do not require large capital costs but ultimately the usage charges can be cost-prohibitive. As a result, CCRTA acquired a radio frequency recently abandoned by the local fire department, and acquired funding to build two new radio towers to achieve Cape-wide coverage. There would likely have been a project delay without the availability of this radio frequency.

VI. Data and Statistics

The success of this project will be determined in several years. Success will be measured by the impact the completed technology system has on the consumption, efficiency and effectiveness of intermodal passenger transportation throughout the Cape Cod region. To date, no quantitative data has been evaluated to measure impacts. However, anecdotal information supports increased driver safety, less negative impact from employee turnover, quicker identification and correction for lost drivers, and precise information to more satisfactorily resolve customer complaints and problems.

VII. Evaluation

The CCRTA technology system provides many "lessons learned" because of the many technologies to be employed and the system's broad-based goals. The lessons include:

- The consortium expanded the funding opportunities, lowered procurement costs through group procurements, and increased negotiation leverage. Also, group procurements greatly increase inter-system technology integration.
- Projects require effective leadership to be successful. The project manager, operations manager and assistant administrator are strong, experienced project champions able to attract funding and successfully complete many public and private partnerships.
- Innovative financing is key. The project leadership, its broad intermodal impact and many partnerships have enabled the assembly of several different funding sources.
- Open architecture and flexible integration for various system components are critical for integrating with other public and private transit systems and organizations.
- A high capacity, expandable infrastructure of computers, networks and communications is needed up front on which to build.
- Technologies originally developed to support urban transit services are many times not appropriate for rural transit. Technology products commonly used in the taxicab industry appear to be cost-effective, easily integrated, and easy-to-use.
- Funding regulations may be outdated in their application to technology product developments. For example, the state transit capital program funded radios and computers, so CCRTA had to convince program administrators that MDCs (Mobile Data Computers) were both in order to use the funding.

VIII. Transferability

Although the CCRTA serves a popular tourist destination, its has much broader application than transit operators in tourist markets. The CCRTA provides a fine example of a transit system that intends to integrate its services with different transit systems, modes, and industries. The CCRTA shows that the infrastructure for such an expansive integration must first be meticulously installed. CCRTA built a digital communication system that reaches their service area, and beyond, and has designated that the software, hardware (especially in-vehicle devices), and communication components be based on an open architecture. They view the communication system as the base of their technology pyramid.

CCRTA has demonstrated the need for broad appeal in designing an ambitious technology system. They have worked with other transit systems, private transit operators, local highway officials, the MPO (Metropolitan Planning Organization), universities, and other partners to design a system that will be integrated and have broad impacts. The federal, state and local funding needed to implement the ambitious technology system have been forthcoming based on this broad appeal, and the CCRTA has been able to form a valuable consortium to enhance procurements. They have also explored integration of a planned transit smart card system with local retailers and banks. CCRTA is certainly "pushing the envelope" in integrating their technology system with that of other transit and highway systems, and businesses.

Case Study Report Summary: #4: Capital Area Regional Transit System

I. Agency/Organization

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II. Summary Statement/Highlights

In 1994, the Capital Area Rural Transportation System (CARTS) started investing in technology by procuring demand-responsive software for its system. In 1998, CARTS partnered with a local utility authority to gain a state of the art communications network for its nine counties. This radio system gave CARTS the capacity and coverage area to allow CARTS to install mobile data terminals (MDTs) for its system. CARTS is currently initiating activities to procure MDTs. Over a period of six years, CARTS has built up its infrastructure, including installation of:

- Software and hardware,
- Dispatch center designed to facilitate the job of dispatching,
- Skilled well trained staff, and
- A radio system capable of digital communications.

There are two technologies that were investigated during this field visit. The first is the DRT software. CARTS was one of the first rural transit systems in the United States to implement and successfully use DRT software. The second technology is the CARTS voice and digital communications system that provides coverage throughout their service area. This radio system resulted from an agreement with the Lower Colorado River Authority (LCRA) to share a state-of-the-art radio system.

III. Background

CARTS is a large rural transit system covering nine counties of Central Texas. CARTS provides approximately 1,000 one-way trips daily. They provide a wide range of services, including fixed-route service in four cities and towns of between 5,000 and 40,000 population, commuter service to Austin, fixed- route between towns, fixed scheduled service, and paratransit throughout the nine counties. CARTS operates about 60 vehicles including paratransit vans, fixed-route buses, and rubber tire trolleys.

The Executive Director believed that his system was large enough to justify computerized scheduling software. The effort was lead by the Director, who felt that the technology would allow him to gain more control over the operation. It is clear that the Executive Director was the leader in all facets of the conceptual design. This conceptual process began in August 1993, when CARTS hired a consultant to assist with the development of a Request for Proposal (RFP) for the procurement of a vendor for the software.

IV. Goals and Objectives

CARTS management articulated a number of specific goals/reasons for investing in the two technologies. CARTS had two primary goals for the software project, as well as a number of secondary goals. The primary goals included:

- Control/Uniform Service -- Management wanted a tool that required staff to treat all customers in a similar manner, in terms of trip reservations and scheduling. Management felt that this tool would give them better control over the system.
- Consolidation of Dispatching -- CARTS needed software to assist staff in consolidating the dispatch of 60 vehicles in a new dispatch center. Previously there were six separate dispatch centers throughout the service area. This was reduced to three.

Other goals for the paratransit software included:

- Improved productivity.
- Reduction of dependency on one or two individuals.
- Organization of client files.
- Improved reporting and record keeping.

CARTS goals for its radio system included:

- Improving radio coverage throughout the service area so that the central dispatch office can communicate at all times with all drivers.
- Reducing down time due to technical problems and reducing staff time maintaining the system.
- Gaining digital capability for the future use of MDTs.

V. NARRATIVE DESCRIPTION

This section first describes the technology and its usage, followed by; a review of how the project came into being, the procurement process, implementation**,** barriers that had to be overcome and the key ingredients to success.

There are two technologies that were reviewed during the field visit. The first was the DRT software that CARTS purchased in 1994. The second major technology investigated in this review was the radio system, installed in 1998, and its advanced technology capabilities.

In 1994, CARTS purchased a then state of the art software package typically used by larger urban paratransit systems. CARTS was one of the first rural transit systems to procure and successfully implement DRT software. Three to four reservation agents and two dispatchers for the majority of the CARTS system use the software in the automated mode. As is typical of this type of software, it has a component to register users, accept reservations, schedule and provide dispatching assistance. CARTS requires each driver to radio in each pick-up and each drop-off, generating significant radio traffic.

CARTS invested in a radio system owned and managed by the LCRA (Lower Colorado River Authority), a 15-county governmental utility that developed its own state-of-the-art radio system. The system offered CARTS clear channels over their entire nine county service area, digital channels for future MDTs, 24-hour monitoring of all channels, an emergency signal for drivers, and all maintenance. The 900 megahertz system allows for dispatch to talk to individual vehicles, patch the radio into telephone lines, and fully coordinate with other governments and law enforcement entities for disaster relief efforts.

CARTS initiated each of these technologies on their own, through the efforts of the Executive Director. The Director determined the need, the type, and use of the software. The Director set the goals as well, with long-term operational changes in mind. No other entities were involved in the efforts.

Management hired a consultant experienced in procuring paratransit software to develop the RFP for the software. Once this was completed, the Director managed separate procurements of software, hardware, and networking services. These were conducted using standard procurement practices.

The radio system was procured through an interlocal agreement with the LCRA, both being governmental agencies. The Director, who had 20 years of experience in working with various radio systems in Central Texas, determined that this system would meet all the system's current and future needs.

Management stated that the first phase of the project cost was $80,000. Typical funding sources were used, including Federal Transit Administration Section 5311 funds, a variety of contracts, and local funding. The radio system costs were similar to the cost of the previous radio system which was very inferior compared to the new LCRA system. The Director stated that CARTS’s costs for the equipment was lower than they could have procured it for outside of LCRA. Operating funds are used to pay for the radio system.

Management put in a significant effort to ensure that the system would operate properly from the very beginning of use. The procurement was conducted in mid-1993 with an early 1994 implementation. The Director felt that training including advanced training for certain staff members was absolutely essential to the successful implementation.

CARTS did encounter a number of barriers/obstacles that they managed to overcome without delaying the system deployment. The Executive Director described these barriers.

- Multiple vendors - In order to reduce costs, management decided to split the procurement into three separate components and be their own project manager rather than have the primary vendor (software) be responsible for all components. The result was increased costs, more staff time needed, and less responsiveness from the vendors.

- Reporting needs - Management has not been satisfied with reports generated by the system, and is still working to develop better reports. Many reports are not as accurate as CARTS requires.
- Software upgrades and support - The upgrade of the software from DOS to Windows® has taken far longer than expected. The upgrade was accomplished over an eight-month period. Staff are continuing to resolve problems and learn the new software. Support is typically slow.
- High cost to maintain system - In one year, CARTS paid approximately $50,000 in support and upgrade costs. These annual costs are typically less for CARTS, however the high maintenance costs are becoming a significant problem.
- Resistance from drivers and dispatchers - There was initial reluctance from staff to use the software as intended.

The Executive Director believed that there were a number of key elements to success.

- Competent Staff - Staff is willing to change in order to improve, and have significant experience.
- Training of Staff - The Executive Director felt that this was the most important element to successful implementation.
- Leadership/Trust - Leadership must be committed to the project and must be able to articulate project goals.
- Vision for the Future - The Executive Director is already planning the next phase, which includes MDTs.
- Single Vendor - Designate one vendor to be responsible for all aspects of installation and implementation.

In 2000, CARTS will initiate a procurement for mobile data units linked to the system's 900 MHz. radio system. CARTS has a number of uses for the MTDs, including the development of accurate reports, dynamic dispatching to permit immediate response service, and Internet trip requests.

VI. DATA AND STATISTICS

CARTS was not able to produce a comparison of current and historical (before the technology system installation) data. The manager and staff needed to produce such a report were not available.

VII. EVALUATION

Management believes that the most important project goals have been achieved.

- Control/Uniform Service - The procedures for using the software require staff to treat all customers in a similar manner, in terms of trip reservations and scheduling.
- Consolidation of Dispatching - The six separate dispatch centers throughout the service area have been consolidated and reduced to three.

Other goals for the paratransit software included:

- Improved productivity - Productivity changes cannot be reliably attributed to the technology system because there were numerous service design changes during the same period in which the new system was implemented.
- Reduction of dependency on one or two individuals - Several staff members can ably operate the software.
- Organization of client files - The software is based on a relational database structure.
- Improved reporting and record keeping - CARTS is still experiencing problems with reports.

CARTS goals for its radio system included:

- Improving radio coverage - CARTS is able to communicate with all drivers, at all times, throughout the service area.
- Reducing down time - Staff time to maintain the information system has been reduced.
- Digital capability - The CARTS radio system is ready for integration with MDTs.

A number of important transferable lessons were learned through CARTS implementation. These lessons are particularly relevant for small rural transit systems.

- Leadership - A critical element is the leader who is committed to seeing this project through to successful implementation.
- Vendor responsibility - Have the primary vendor be responsible for all aspects of implementation, including hardware, software, and networking.
- Step-by-step process - Implement one technology at a time, become proficient with it, then implement a new technology, rather than trying to implement a sophisticated set of technologies all at once.
- Funding issues - To date, funding has not been a significant issue. The future procurement of new technologies will require additional funding.
- Training - Quality and comprehensive training is a key element for implementation and success.
- Vendor support - The need for vendor support, especially for the first six months is essential to success. Vendor inaction can be a problem. Look for a vendor with a good record of support.

- System reports - Larger systems should consider training an in-house staff person to write the computer generated reports.

VIII. Transferability

CARTS provides useful "lessons learned" that can be applied by almost any transit operator. However, the more specific applications are perhaps the most valuable. CARTS provides an excellent example for larger paratransit systems and those that have an unusually large service area. Using a fully automated DRT software, they were able to consolidate their dispatch functions to reduce the number of dispatch centers, and implement scheduling policies that are fair to their diverse customer base. These achievements are likely to be goals of many large paratransit operations.

Furthermore, CARTS demonstrated much vision. They established a radio system that was an absolute essential for consolidating their dispatch centers, implementing a DRT software, and installing MDTs in the future. Rural transit systems with unusually large service areas should take note that CARTS established this basic radio infrastructure as a base on which to build their future technology and communication systems.

Case Study Report Summary #5: Capital Area Regional Transit System

I. Agency/Organization

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II. SUMMARY STATEMENT/HIGHLIGHTS

The ITS project currently being implemented by Community Transit of Delaware County consists of a number of related elements. The cornerstone of the project consists of customized computer assisted dispatch software and MDTs used to communicate between the transit vehicles and the dispatch base. The dispatch base and the MDTs are linked via a wireless communications network utilizing a cellular digital packet distribution (CDPD) system and customized communications software. The primary objectives of this are to increase the productivity of the system and to provide for improved oversight and monitoring of driver activity and trip status.

Also included in the implementation is a computerized customer ID program which sends visual images of the passengers to the MDTs on the vehicle so that drivers can confirm the identity of the passenger. Another feature is the use of WebTV to enhance communications between health care providers and the transit system relative to trip requests, schedules, and trip status. This is designed to reduce the reliance on telephone calls and thereby freeing up telephone capacity and staff resources.

Another element that is currently in the developmental stage is an automated routing system that can provide routing assistance to dispatchers and drivers.

As of January 2000, the system was in the final stages of a complete rollout of the basic elements of the technology, including the dispatch software, the MDTs, and the related communications hardware and software.

III. BACKGROUND

Community Transit operates in Delaware County, Pennsylvania. It is not a truly rural system, but rather a suburban system that includes some rural areas. However, the type of service operated, the markets being served, and the types of technology being used are relevant to rural and small urban systems. They operate under Pennsylvania's Shared Ride Program, providing trips for seniors over the age of 65 for any trip purpose. Community Transit also provides Medical Assistance trips and administers the Medical Assistance Transportation program for the county. They also provide human service agency transportation under approximately ten service agency contracts.

Community Transit is a private non-profit organization created for the purpose of coordinating the provision of human service transportation in the county. A number of these agencies saw the need to consolidate their transportation functions and to improve coordination among the various providers to control costs and maximize the amount of service being provided to their clients. Community Transit was the result of this effort.

The system has no direct source of funding of their own, but relies primarily on three major funding streams. These are the state's Shared Ride program, the Medical Assistance Program, and the human service agency contracts. In order to serve its primary markets and to continue to meet the needs of the clients it serves, Community Transit must monitor its efficiency and try to boost its productivity in order to provide the maximum amount of transportation that it can for the dollars that are available. This desire to increase productivity was the primary impetus behind the implementation of its technology program.

IV. GOALS AND OBJECTIVES

As stated above, the principal goal of the project was to increase the productivity of the system and be able to serve more trips for a given expenditure of resources. There are a number of facets involved in the increase in productivity. These include improved scheduling, a more flexible real-time dispatching function, and better monitoring of driver performance and activity. As all of the various elements of the project are implemented and become fully operational a number of other objectives will be achieved as well.

The automated picture ID project is driven by the requirements of the Medical Assistance (MA) program. This program is very concerned that passengers obtaining transportation under the program are indeed eligible for the service. When fully operational, the primary function of the picture ID system will be to serve as a means of confirming eligibility for MA transportation. The system wanted an automated passenger identification system that avoided the use of smart cards or other devices that the passengers would be required to carry as this was considered to be a hardship among many of the elderly and disabled recipients of MA transportation. The photo ID system will accomplish the objective of providing positive identification of passengers in order to confirm eligibility without the requirement that the passengers carry some form of card or device with them.

The objectives of the WebTV element of the project include improved communications between health care providers and the transportation system. This is accomplished through reducing the number of phone calls required to order transportation, cancel trips, revise schedules, etc. It is hoped that this will lead to less time spent on the phone by both the health care providers and the transit system, thus freeing staff up to attend to other duties and also freeing up telephone lines for other purposes.

V. NARRATIVE DESCRIPTION

Community Transit's ITS project contains three primary technologies, a computerized scheduling and dispatch system (computer assisted), a mobile communications system and MDTs, and an automated photo ID system.

For the scheduling and dispatching software, Community Transit purchased the source code of a pre-existing proprietary product (Rides Unlimited) and obtained third party support to tailor the product to meet their needs. The product is now known as Queue and has been highly customized to meet the specific needs of Community Transit. The system is now self-supporting with their own software support department. When they purchased the source code, they also obtained the rights to market the product to a limited number of properties throughout Pennsylvania. They are in the process of implementing it at four sites at this time, and will provide technical support to these systems.

A key element of the project is the MDTs that are installed on the buses. They are used to communicate between the drivers and the base station. MDTs are based on touch-screen technology and they do not have keyboards. Drivers use a stylus (basically a wooden pen-like device) for entering data onto the screen. At the start of the day, all driver manifest information is entered into the MDTs. All basic communication relating to trip orders is then sent back and forth via the MDTs rather than the voice radio system. This includes confirmation of all pick-ups and drop-offs and the time and odometer readings corresponding to the pick-ups and drop-offs. Basic changes to trips such as pick-up and drop-off times, destinations, etc. are communicated via the MDT. New trips are also dispatched to the drivers via the MDT.

The trip confirmation information that is entered into the system via the MDT provides confirmation of trip status, helps support the billing function, and indicates driver availability to the dispatcher. The dispatcher is then able to determine in real-time when a driver has completed his scheduled trips and is then available to handle additional trips.

At the time of the site visit in January 2000, the system had not been fully implemented. Only 20 vehicles out of a total fleet of 115 had the technology installed. After several false starts, the system was confident that they had the problems worked out. The MDT project started in September 1997, with the intention of being fully operational by the end of that year. By the spring of 1998, they had 18 vehicles equipped, but the system was put on hold in November of that year primarily due to financial problems experienced by the transit system.

During the early testing, the MDTs have proven to be effective. They provide real-time information feedback on the status of trips that have been assigned to drivers. This is not currently tied to a GPS/AVL system, but AVL could be added rather easily in the future if the need for such a system is identified. Currently, it is not seen as needed. One thing that would probably call for an AVL add-on is if the system were to add more demand response service, particularly same day service. Then, vehicle location would probably be justified, but with current service mix, system management does not believe that AVL can be justified.

The MDT project included the software to manage the messaging between the dispatch base and the vehicles and the communications backbone to support the messaging. The communication system chosen is a cellular digital packet distribution (CDPD) system, Bell Atlantic's Air Bridge. Each vehicle has a CDPD modem and a unit for sending and receiving the CDPD signal. The original idea for communicating to the MDTs was to use the radios. However, they would have needed an entirely new radio system because they were unable to overlay voice and data on the same system with the frequencies they were using. This spurred the decision to go with the CDPD system for communicating to the MDTs.

They have a variety of rate plans with Air Bridge. Each vehicle has a separate IP address and separate account. Some vehicles are on a flat rate with an allowance of up to a specified amount of usage per month, while other vehicles are on an unlimited plan. Each run in the schedule is monitored for usage to make sure it is on the proper rate plan. Some services require a lot of communications while others do not. Group trips with standing orders where a large number of riders are transported regularly between the same two points require significantly less air time than do the more demand responsive occasional trips. Net-Tech software is used to control and coordinate the messaging to the MDTs.

The MDT support for Community Transit's agency billings is also an important function of the system. The MDT software automatically generates all of the billing. Some contracts are billed by mileage. This is picked up from the odometers and electronically entered into the system and associated with the specific trip. The system also generates a number of management reports.

The Medical Assistance program was the driving force behind the automated picture ID project. A camcorder is used to capture a visual image of the clients and enter them into a database. At the time of a pick-up, the driver pulls up the client picture on the vehicle's MDT screen in PCX format. The driver is then able to confirm that the person being transported is the appropriate client and that they are eligible for the trip. If the system tests out, it may be extended beyond the MA program to other programs and contracts that have specific trip eligibility requirements.

Another project is the use of WebTV. This is used as an interface device for entering transportation requests under the frail and elderly transportation program. This is done instead of using the telephone. Rather than tying up phone lines, requests are essentially e-mailed to Community Transit using the WebTV system. If this works up to expectations, it may also be extended to other programs. This was a special project in conjunction with the Crozier Medical Center and was funded by a U.S. Department of Commerce grant.

Community Transit is also in the early stages of testing the implementation of an automated routing system. They are now looking at and testing a system called RIMMS—Resources in Motion Management System. This is a GIS system with a software engine that can make routing decisions based on time-of-day. It is a routing software system that was developed for the courier and trucking industries. It includes an address lookup function and a route selection module. It is now being tested, but has not yet been tied to the other technologies in use at Community Transit. Eventually, it could be integrated with the MDTs and the scheduling software.

Drivers now have flexibility in routing decisions with support from dispatch. The RIMMS system, when fully implemented, would have the capability of sending routing instructions to the drivers over the MDT screen. There is a time-of-day component that recognizes different traffic conditions at different times of the day. The system has a database that includes landmarks as well as the street network. This would enable the system to tell drivers things like "turn left at Main St., immediately after passing under the overpass." It is anticipated that if successful, the RIMMS would serve as a resource to support the drivers and dispatchers rather than taking the primary decision-making out of their hands.

To date, Community Transit's ITS projects have cost just under $1 million. They have received $200,000 from the FTA, $240,000 from the state, $90,000 from a private foundation, and $428,000 from the county's CDBG funds. These funds have covered the capital costs, the software development, and the various software licenses.

VI. Data and Statistics

Community Transit is currently involved in the final rollout of the primary elements of the technology, including the Queue dispatch software and the MDTs. As a result, it is too early to conduct any quantitative analysis of the technology. The first phase of the technology implementation has gone well. System management is satisfied with the results of the testing of the software and MDTs on the first 20 or so vehicles and they consider it to be very successful. Acceptance of the other elements including the WebTV project and the photo ID system has also been positive and it is hoped that once fully implemented, the technologies will live up to their expectations and help the system achieve its objectives. There was some initial staff resistance to the technology, particularly on the part of the drivers who were concerned about the "big brother" aspect of the MDTs, but that appears to largely have been dealt with by management.

As stated previously, the primary overall objective of the technology was to help the system increase its productivity. Community Transit currently has a productivity of approximately 2.00 to 2.10 passengers per vehicle hour. Their target is to get this up to 3.00 to 4.00 passengers per vehicle hour, and hope they can do so through the operational improvements that can be achieved from the computer-assisted dispatching and improved driver monitoring and communications. It will probably take a full year of operation under full technology deployment to obtain a reliable quantitative analysis of the project's impacts.

VII. Evaluation

Too often technology is perceived to be an "elective", something that is nice to do if you have the money, but not essential to the success of the agency. This is the same way that some agencies view marketing. This attitude was encountered at Community Transit during the early stages of the implementation and testing of the technologies involved in their ITS project. As a result they were forced to delay the actual implementation of the technology by approximately two years when the agency encountered some serious financial problems.

When a technology is able to provide a definite solution to an identified problem, it is important to communicate to the leadership of the agency that the technology should not be viewed as experimental, but as a definite solution. This can be difficult to do with a largely unproven technology. Management needs to be firm as to what the overall benefits of the technology application are and be able to show what positives the technology will provide to the agency as a partial solution to the problems it faces. It is important to identify firm deadlines and a solid schedule for implementation of the solution and then keep to them.

Community Transit also came to recognize that, particularly with a complex technology implementation such as theirs, there is a need to dedicate a manager to the project. It does not work nearly as well when the job of implementing the technology is simply someone's "other hat." At first, that is what Community Transit did and no single individual was assigned full time to making the technology project happen. The technology issue was always taking the back seat to getting the service out and trying to deal with day-to-day problems. In the long run, the system would have saved money by dedicating a manager to the technology project earlier in the game. They have now overcome that problem and are moving ahead with completion of the installation. One problem with the approach that was taken initially is that by the time they are getting to full deployment, they are using three year-old technology, which is no longer state-of-the-art.

Another key to the success of the project has been the development of a very clear technical specification for each element of the project. Along with this was the involvement of specialists in each separate technical area as opposed to having one firm provide everything under a single procurement contract. There may be some risk involved with this in terms of the need to get the separate parts to work in concert and communicate with each other properly. However, this risk appears to be balanced against the benefits of getting each element to contain exactly what you want and be the most appropriate for local circumstances.

VIII. TRANSFERABILITY

While the specific combination of technology elements might not prove to be directly transferable to another system, some of the experience and lessons learned by Community Transit can be of direct value to other systems contemplating the implementation of a complex set of technologies.

One lesson relates to the advantages of having a full-time manager whose only responsibilities involve the success of the technology implementation. This could be an existing staff member whose responsibilities are shifted to oversight during the critical implementation phase, or a new staff person hired specifically for the purpose of overseeing the project. Obviously, some agencies may not be able to afford this approach. However, during the planning phase an important consideration needs to be the level of complexity of the project and whether or not the lack of a full-time project manager will seriously hamper the system's ability to conduct a successful implementation.

If the level of complexity is such that a full-time manager appears to be warranted, it will probably save money and significantly reduce problems in the long run to take the actions necessary to dedicate the required staff resources. If the staff resources simply can not be dedicated, then the system may wish to scale back the complexity of its project to meet the resources that are available. The two years of delay in implementing the project and beginning to realize the positive results were largely the result of the fact that Community Transit failed to dedicate the needed staff resources during the early stages of the project.

The other lesson to be learned from the Community Transit experience deals with the way in which each specific element of the technology application was defined and customized to meet the requirements and desires of Community Transit and to comply with the local environment. The communications backbone was based on readily available technology in the southeastern Pennsylvania area and customized to fit the needs of Community Transit's application of that technology. Likewise, the MDTs were specified to the requirements of the system and then communications software that could be tailored to work with the CDPD communications system, the selected MDTs and the customized dispatch software was obtained. This approach has been taken with all of the additional elements that have been or are being added to the basic system. This approach probably takes slightly longer to implement and may require a higher level of staff resources on the part of the transit system, but it appears that it has been successful in terms of ending up with a workable system that is meeting the objectives outlined for the technology.

Case Study Report Summary #6: Flagler Senior Services

I. Agency/Organization

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II. Summary Statement/Highlights

In October 1998, Flagler Senior Services Inc (FSS), the FTA Section 5311 rural transit provider in Flagler County, Florida, implemented the first of its proposed technological advances. Phase I included implementation of DRT software that would drive the other technologies. Phase II is the implementation of the AVL technology, and Phase III will be installation of mobile data terminals. The DRT software has been in use for two years and an AVL demonstration with three vehicles is in progress. MDTs are in the planning stage.

III. Background

FSS is a non-profit agency that provides a variety of services to seniors and in the case of transportation, the general public, as well. The system operates 16 peak vehicles in Flagler County, an area of 487 square miles. The system averages about 350 one-way trips daily (Monday through Friday). The system is both general public and human service funded, including Florida Transportation Disadvantaged (TD) funds, Medicaid, and Title III funding (i.e., elderly services).

The conceptual process revolved around the Executive Director, who determined the need for technology, examined the options available and selected the most appropriate technologies. In addition, he developed the partnership with the two other operators involved in this project. It is clear that the Executive Director was the leader in all facets of the conceptual design. This conceptual process began in August 1996, through a discussion with a vendor. The Executive Director examined all of the major products available within FSS's price range, and analyzed their capabilities.

IV. Goals and Objectives

The current Executive Director of FSS initiated the use of technology based on his desire to reduce paperwork and be able to collect, report and analyze data. While these were his primary goals, other reasons for investing in technology included: a visual tool for dispatchers; controlling of costs; improving productivity; and reducing dependency on one or two individuals. He stated that saving money was not a specific goal of the project, however cost savings is implied in a number of these secondary goals.

V. NARRATIVE DESCRIPTION

The narrative description describes the technology and its usage, followed by; a review of how the project came into being, the procurement process, implementation**,** barriers that FSS had to overcome, and the key ingredients to success.

FSS is employing fully automated DRT software that provides all of the standard features of this type of software**.** The software is programmed using MapInfo as the GIS package. The software operates in an automated scheduling mode, or in a computer-assist mode; currently FSS is using the software in the computer-assist mode.

In addition to the use of this software, FSS has equipped three vehicles with automatic vehicle location transponders (AVL) to track the location and schedule progress of vehicles. As of the date of the site visit, use of the AVL equipment had not been incorporated into the system. It is expected that AVL will be used by the dispatcher to determine if a driver is near a pick-up point, without having to contact the driver. The dispatcher will also be able to use AVL to assist in identifying vehicles available for will-call trips (i.e., clients who do not know the time of their return trip, as in medical appointments), last minute requests, and changes due to vehicle accidents or shortages.

FSS acted as lead agency and procurement manager, but other rural transit programs also were involved in the effort. This made the effort more difficult, requiring FSS to coordinate multiple interests. At one point, one of the other transit system managers left, slowing the process down by about six months due to a need for educating the new agency director.

The process from conception to implementation took over two years. The Executive Director determined a need for technology in August 1996. The procurement was conducted in April 1998 and FSS began using the software in October 1998, with “bugs” removed by November.

Management initiated a process by which the system could automate over time in a phased approach. The Executive Director determined that new technology should be implemented in steps, due to both funding constraints and the desire not to place too much of a burden on staff. The first step was the automated software, with hardware that was procured separately. This was followed by the purchase of Automatic Vehicle Locator (AVL) technology, which is in place in three vehicles on a demonstration basis.

The procurement was initiated incrementally, as funds became available. Management had conducted detailed research regarding their needs and the capabilities of the existing packages. Management selected a package through the procurement process and then negotiated a contract with the winning vendor.

Management stated that the first phase of the project cost $60,000. This included all software, hardware, training, installation and on-going support. The second phase costs, which included the development of the AVL system, were $30,000 as of January 2000. Typical funding sources were used, including FTA Section 5311 funds, a variety of Florida human service contracts, and local funding.

Management took great effort to ensure that the system would operate properly from the beginning of use. The contract was awarded May and the implementation began in August and ended in October. Following are some of the issues raised by management.

The Director feels that training is absolutely essential to a successful implementation. He stated that the next time they implement new technology they will concentrate more on the vendor's training record and experience. The vendor provided advanced training to allow FSS staff to learn the "nuances" of the software. FSS has worked closely with the vendor to ensure that all staff are receiving the training they need. The Executive Director stated that the vendor has been very responsive to their needs.

FSS did encounter a number of barriers/obstacles that they managed to overcome, without delaying the system deployment. The Executive Director described these barriers.

- Partners - In any planning process, the more key participants there are, the more difficult the development and implementation. This was the case with this procurement. A consensus was developed over six months. However, after the representative of one of the key partner organizations left his position, it took another six months to get that partner organization back in to the consortium. In order to overcome this barrier, time had to be spent organizing and educating the participants.
- Fear of Change - The Executive Director stated that while his organization is familiar with change, there was still some trepidation in going from manual to a fully automated scheduling/routing system. Staff have learned how to cope with change. The Executive Director spends considerable time in working with staff and in training programs.
- Political Issues - One state agency was reluctant to work with FSS. This was ultimately resolved through discussions and education.

The Executive Director felt that there were a number of key elements to success including:

- Competent Staff - The staff is willing to change in order to improve. They are as committed to the project as management.
- Training of Staff - The Executive Director felt that staff training was the most important element to successful implementation.
- Leadership/Trust - Leadership must be committed to the project and must be able to articulate project goals.
- Vision for the Future - The Executive Director is already planning the next phase. After completion of the AVL system, MDTs planned for installation.
- Quality Hardware - The Executive Director stated that it is very important to get the best hardware possible. With all the things that can go wrong in a major technology installation, it is unwise to risk using lower quality hardware.
- Quality Support - Critical to success has been the support received by the software

vendor. The vendor has been responsive and works very well with FSS.

VI. DATA AND STATISTICS

The system was able to produce historical productivity data, which is a critical indicator. One-way trips per vehicle hour have increased from a range of 2.3-2.7, to 3.1-3.4. The organization is in the middle of a complete cost analysis.

VII. EVALUATION

Management believes that the most important project goals have been achieved, including:

- Reduced paperwork - Management feels that this has been accomplished by reducing the data entry process.
- Improved collection, reporting and analysis of data - FSS now produces a wide variety of reports for contractors and management.
- Dispatchers tool - The dispatchers are using the software and believe state that it is an improvement over the manual system.
- Improved productivity - Management has documented the increase in system productivity based on better scheduling.
- Control costs - Through the productivity improvements, management has been able to control costs. In addition, dispatcher and driver overtime has been reduced.
- Reduce dependency on one or two individuals - Management has been training staff in order to meet this goal.

A number of important transferable lessons were learned through FSS's implementation. These lessons are particularly relevant for small rural transit systems.

- Build a consensus - In the case of FSS, a consortium was formed to procure software. This allowed FSS to get a lower price for their technology.
- Leadership - A critical element is the leader who is committed to seeing this project through to successful implementation.
- Step-by-step process - For small systems, the step-by-step approach may make the technology affordable. From an operating perspective it also makes sense to implement one step at a time. Prior to the AVL, staff became proficient in the use of the primary technology, paratransit software.
- Selection of technology - Care must be taken in selecting the technologies most appropriate for system needs. Set goals and select technologies that will meet those goals.
- Funding issues - Even a relatively small system can afford a quality software package if they use a step-by-step process.
- Training - Management felt that even more training would be better, and continually emphasized this issue.
- Vendor Support - The need for vendor support, especially for the first six months is essential to success. Look for a vendor with a good record of support.

V. TRANSFERABILITY

The evaluation above describes key elements to success that almost any transit system can apply. A few of these lessons are especially notable for small transit systems. The lack of funding is often the primary reason cited by transit systems for not investing in technology. However, FSS shows that a small transit system can use a phased implementation approach and the support of a consortium of other transit systems to yield a quality DRT software and a relatively advanced technology system that includes AVL, possibly MDTs.