

Costs And Benefits Of

Advanced Public Transportation Systems

At DART FIRST STATE

prepared for

Delaware Center For Transportation

and

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by

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Executive Summary

This project examined the costs and benefits of new technologies implemented at DART First State. Nationally the technologies come under the title of Advanced Public Transportation Systems (APTS). APTS technologies that were considered here include:

- Automatic Vehicle Location
- Operations Software
- Mobile Data Terminals
- Silent alarms/covert microphones/surveillance cameras
- Automated passenger information systems
- Automatic passenger counters
- Vehicle Diagnostics

There is a very high degree of integration between all these pieces, brought together by a range of management software.

In an examination of information available about APTS implementation around the country numerous benefits of APTS were referenced. National guidelines available for the evaluation of APTS and efforts were made in this project to conduct the cost/benefit analysis to these guidelines.

Included in national evaluation guidelines is the establishment of an evaluation framework that provides the context for the evaluation for a specific transit agency. The primary higher level goals of DART First State's APTS technology implementation were identified and are as follows:

- To improve communications with transit operators toward better response, and improved dispatching
- To have the ability to track the locations of transit vehicles in real time towards better dispatching and improved customer service
- Through gains in efficiency, address growing demand for services without adding additional personnel or equipment. Improve quality of service.
- Improve convenience for transit customers and improve visibility of transit services thru the implementation of real time passenger information systems.
- To have the ability to track the location of transit vehicles in real time towards better planning.
- Improve safety, emergency response, and incident management.
- Increase ridership in support of the department's Long Range Transportation Plan.
- Improve handling of complaints and disputes among the public, operators, and management.
- Through use of technology realize cost and quality benefits in regards to maintenance of transit vehicles.

- Provide a more accessible, responsive, and efficient transportation system by using capital funds to reduce long term operating expenses.
- Provide more effective management and accountability.

Benefits were examined in terms of these goals. DART First State has seen significant increase in the demand for transit services particularly in the demand for paratransit service. Transit ridership for fixed routing has increased by about 17% in the last 5 years. Para-transit ridership has increase by 43% in the last 5 years. It is essential that DART becomes more creative and efficient to deal with increasing demand. The largest population growth within Delaware has been in lower density areas, particularly in Sussex County. The need for services for the elderly and disabled is growing. Better management tools are required to improve efficiency and service and to keep pace with the demand.

There have been initial start up costs for all APTS systems of about \$7.5 million over the last 5 years. Ongoing software and hardware maintenance costs, and estimated replacement costs are about \$870,000 per year.

Benefits are identified and discussed in this report. There are several areas where benefits of the APTS technology could be quantified. Based on increased efficiency as evidenced from decreases in pay to platform hours, and reduction in overtime and premium hours, savings are estimated to be about \$600,000 each year. Workman's Compensation costs have drastically decreased with the addition of on-board video and audio equipment, with this past year costs about \$1 million dollars less than previous years. There are estimated cost savings of about \$200,000 per year from not having to hire new scheduling personnel that now schedule 6 times the number of paratransit trips per day than 5 years ago.

Accidents are not uncommon nor are false claims. On board video cameras facing the path of the vehicles and within the vehicle, remote data terminals, on-board audio, and other monitoring systems provide information that is needed to prevent in some cases massive losses in man hours, legal fees, settlements, and liabilities. Savings are estimated conservatively at \$500,000 per year from these monitoring capabilities. There are other savings referenced in areas such as data collection costs, vehicle costs, and from improved decision making as a result of the information the APTS provides for effective operations changes. APTS allows administrators, managers, and planners to work much smarter and there are examples where vastly improved operations information, detailed knowledge of how money is spent, and the ability to predict costs of policies, have saved large sums of money. Savings as a result of APTS at DART is estimated to be about \$2.3 million a year.

It is clear that where benefits can be quantified, the resulting savings each year can easily offset ongoing costs and even recoup the initial investment cost of APTS. But there are many important benefits of APTS that are discussed that cannot easily be quantified and include:

- Significantly improved safety for passengers and operators.
- Significant improvements in the quality of service.
- Increased ridership through advanced passenger information systems and a better product.
- The ability to handle greatly increased paratransit demand while improving quality of service.
- Better decision control and management capabilities.
- Much more effective conflict resolution between management and labor.
- Much more effective and informed handling of complaints by the public.

The APTS technologies and information systems are highly integrated and achieve a mode of operation and degree of decision control and capabilities that did not exist before. There is not only more information and communications of a higher quality, but that information is highly accessible to operations and management personnel in real time. There has been a great leap forward. For instance, for dynamic paratransit routing, DART has gone from a situation where operations personnel with difficulty communicated with drivers to ask them whether they could accommodate a new trip, to a situation where operations personnel can see on real time computer maps where all vehicles are and all clients are at any moment in time, and have systems that can predict accurately what changes in route can be accommodated, and can then communicate with drivers very effectively and reliably using on board remote data terminals. Safety of drivers and passengers is vastly improved. On board audio and video, silent alarms and other surveillance, and the accurate location of all vehicles is available at any time.

The implementation of APTS at DART First State has achieved all goals for it's implementation and is a real success story.

Introduction

About \$7.5 million has been spent in the last few years at DART First State (DART) for the implementation of Advanced Public Transportation Systems (APTS). In light of this large investment and approximately \$870,000 per year in on-going costs to maintain and replace the systems, the Delaware Transportation Company (DTC) through the Delaware Center for Transportation at the University of Delaware, sponsored this study to examine the benefits of the system after the first few years of operation.

This report begins with a discussion of APTS and the implementation at DART. Background is provided on what the goals of the implementation are.

A review of APTS technology across the United States was conducted as part of the project and is included.

The Federal Transit Administration has produced guidelines for the evaluation of APTS and these guidelines are discussed and efforts were made in this project to conform to the suggested method of performing evaluations. An evaluation plan was developed, identifying indicators of success with DART's higher level goals for APTS implementation.

Project personnel met with several representatives of DART and examined a large amount of data provided to describe, and where possible quantify, benefits in relation to goals. Costs were then compared with benefits.

APTS Technology At DART First State

Advanced Public Transportation Systems (APTS)

This project focuses on an evaluation of Automated Vehicle Locator (AVL), dispatching and routing software and hardware systems, security systems and related technologies that have been recently (May 2001) implemented at DART First State. These technologies are addressed and evaluated nationally under the category of Advanced Public Transportation Systems (APTS). APTS technologies include:

- Automatic vehicle location
- Operations software
- Mobile data terminals
- Silent alarms/covert microphones/surveillance cameras
- Automatic passenger counters
- Automated passenger information
- Vehicle diagnostics
- Traffic signal priority
- Electronic fare payment
- Intelligent vehicle initiatives

DART First State has implemented technology in most of the areas listed above. This project focuses primarily on the cost-benefit evaluation of the following technologies:

- Scheduling and dispatch software and systems
- Automated Vehicle Locator (AVL) and capabilities it supports
- Communications equipment, particularly mobile data terminals
- Security equipment such as silent alarm, cameras, etc.
- Real time rider information systems

The primary technology this examination addresses is the ability to track the exact location of vehicles in real time (AVL) but there is a large degree of integration across purposes.

In this chapter the various APTS technologies will be briefly introduced with a description of DART technology implementations in each area.

Automated Vehicle Location Systems (AVL)

Automated Vehicle Location technology includes the systems and hardware to broadcast the spatial coordinates on the ground of any vehicle, and is the foundation of several efforts. The actual real time position of each transit vehicle is calculated and relayed to a control center. The three principal methods of determining vehicle position are using signals from signposts, dead-reckoning (calculation from a known position, odometers,

compass readings), and using signals from global positioning systems (GPS). GPS is now the most common method used and is used by DART First State. AVL systems that capture the real time location of transit vehicles can be used by transit personnel and the public in many ways. AVL is the basic building block for other transit APTS applications that depend on knowing vehicle locations. AVL provides the location data needed for operations software, silent alarms, automatic passenger counters, real-time passenger information, in-vehicle signs and annunciators, and traffic signal priority. AVL provides transit agencies with vast amounts of accurate data that could not be afforded by manual means. Vehicle location data are used by many transit personnel, including dispatchers, vehicle operators, schedulers, planners, maintenance staff, customer information staff, and street supervisors. Major benefits are in areas of dispatching (particularly paratransit), incident management, and schedule adherence.

Most DART buses and paratransit vehicles are now equipped with AVL systems. The Orbital Technologies' SmartTrack system allows for the determination and use of the location of vehicles in the field, and the locations can be viewed on computerized maps and displayed on mobile data terminals relative to other information such as calls for service and the location of paratransit clients. Paratransit dispatchers are able to locate the most appropriate vehicle to carry out manifests by looking at vehicles on real time AVL workstations. The AVL SmartTrack system interfaces with rider amenities already in DART First State buses, such as digital readouts and voice announcement of stops. AVL systems can also be interfaced to real time passenger information applications hosted on Internet web sites. AVL systems are linked to automatic passenger counters that compile ridership surveys on a complete and continuous basis.

Operations Software

Operations software is used to develop and display information for a variety of transit decision making activities. Software is a key element of APTS installations and geographical information systems (GIS) are a major software component. Software can combine AVL data with map data and display them on dispatchers' computer monitors, together with information such as vehicle status, schedule adherence, and incident information, and systems can be easily customized by each transit agency. Determining customer routes for fixed routes and optimum strategies for serving paratransit customers can be calculated and displayed quickly. Systems can be used for dispatching, record keeping, and billing. Operations software can relate large amounts of data needed to prepare and adjust schedules and can automatically record and print or display a variety of reports. Higher end systems that are able to receive trip requests by touch tone phone, schedule trips, and transmit vehicle schedules to operators without manual intervention offer even greater potential for enhanced efficiency.

DART First State uses the TRAPEZE software suite that provides several different capabilities in various areas. It enables DART to take paratransit trip requests, schedule paratransit service, and dispatch the service on a daily basis. Numerous reports can be generated about past service and planned service.

The fixed route module of TRAPEZE compiles all of the service requirements and produces a run cut for operator bidding. This module can be combined with the paratransit module to obtain service area information and ADA standards. The fixed route module also allows DART to keep an inventory of bus stops and routes throughout the state. This inventory is used extensively when dealing with requests for additional stops, route adjustments, or general questions from the public. There is a complaint/commendation module in TRAPEZE that tracks customer feedback and attributes it to specific runs, routes, or trips within trapeze. This allows DART to be more proactive in the process when making changes or run adjustments. There is also an FX Ops module that tracks all of the work performed by each fixed route operator and using an intricate costing routine, calculates the pay hours for each employee on a daily/weekly basis.

Mobile Data Terminals and Communications

A mobile data terminal is an in-vehicle device with a small screen to display messages and text, plus a series of buttons to send preset messages to the dispatch center. When installed they are the primary communications means between operators and dispatchers. In AVL equipped vehicles the terminals usually include computerized capabilities that calculate vehicle location, compare location and time to the schedule, and determine the vehicle's schedule adherence that can be displayed on the screen. Voice or data messages can be directed to an individual bus, specific groups of buses, or the entire fleet. Mobile data terminals can coordinate vehicle to vehicle transfers of passengers on intersecting routes. They can be useful in providing routing instructions and messages to demand response vehicles, can provide an electronic manifest of customer pick-ups and drop-offs, and can facilitate additions and deletions to routes in real time.

Mobile data terminals are installed on all DART buses and paratransit vehicles, and allow messages to instantly be transmitted between operators and management personnel.

In 1998, DTC undertook the task of replacing the existing outdated radio system with a state of the art digital radio system. Conversion to the Statewide 800 MHZ system was a required effort outside of any other technologies that were to be integrated with it. Radio/voice systems are integrated with the mobile data terminals.

Silent Alarms / Covert Microphones / Surveillance Cameras

Silent alarms, covert microphones, and surveillance cameras installed in vehicles enhance the safety and feeling of security of operators and passengers. All DART fixed route buses are equipped with on board cameras, alarms, and audio monitors. There are cameras also on the buses showing the path in front. SmartTrack systems can provide calls to Street supervisors and can be used for covert communications (such as silent alarms) to have necessary law and emergency authorities in route to the bus prior to any communication with the bus operator

Automated passenger information

There are several types of passenger information and methods of delivery. Information can be provided to customers and potential customers for trip planning, while at a bus stop, or while they are on-board. Information can include real-time vehicle arrivals and full trip planning itineraries. Information can be delivered by telephone, the internet, pagers, personal digital assistants, cable television, kiosks, smart signs at bus stops, signs on the bus, or on-board automated voice announcements. Accurate information, especially real-time information, reduces the anxiety of transit use and is particularly important for longer headway routes. Real-time vehicle arrival information allows passengers to time their arrival at stops, thereby reducing their wait time and exposure to weather and undesirable elements.

At major stops in the DART system, real time passenger information can be broadcast to bus shelters allowing riders to see when the next bus is expected and the current routes and schedules serving bus stops. The NextBus System using the satellite tracking systems (global positioning systems GPS) are the basis of real-time electronic display message boards that take into account the actual position of the buses on routes, their next stops, and known traffic patterns to arrive at continuously updated estimates of bus arrival times. These message boards have been used at Delaware Resort areas and have contributed to a 13% increase in Resort Service ridership. When the public can be made more aware of bus service they may better consider it for their travel choices and can make more efficient use of their time.

Another DART initiative, the “Remote Talking Sign” System assists blind and visually impaired bus riders. A compact, hand controlled receiver verbally tells the user the route number and destination of the bus as it approaches a bus stop from up to 100 feet away. The system utilizes signals sent by infrared light beams from transmitters permanently installed in buses.

Real time passenger information is integrated with DART’s operations software and is available to dispatchers and customer service personnel, and is also available on the Internet.

Vehicle Diagnostics

Vehicle diagnostics provide information to the dispatch center and the maintenance department about the condition of certain vehicle components. Sensors are connected to components to monitor engine temperature, oil pressure, brakes, and tire pressure. Diagnostic information can be relayed in real time so appropriate actions can be taken. Attention to problems identified before failures occur should improve service reliability by reducing the number of vehicle breakdowns and resulting service delays. Early detection can also prevent potentially serious situations or costly repairs or replacements.

DART has sensors on some vehicles that monitor engine temperature.

Electronic Fare Payment

Magnetic strip fare cards or “smart cards” offer convenience to the rider so there is no need for exact change or standing in line to purchase tokens or tickets. Transit agencies can benefit from the reduction in the labor intensive manual handling of cash, tickets, or tokens and the reduced chance of fraud or theft. Increased revenues result from reduced fare evasion, interest on the money between the time a card is purchased and used up, and possibly from increased ridership. Smart card systems provide benefits of security for lost or stolen cards, discounts for frequent transit use, greater flexibility in fare products, and reduced paper transfers and equipment maintenance. Smart cards permit collection of more detailed ridership data for use in route planning and travel time studies, and allow development of a seamless regional, multi-agency, multi-application system. Use of smart cards also reduces boarding times.

DART has fully implemented a Smart Card System, though electronic fare payment systems were not addressed in this evaluation.

Traffic Signal Priority

Traffic signal priority allows transit vehicles to progress along their routes with less delay at signalized intersections equipped with specialized receivers and controllers. A transit vehicle approaching a signalized intersection transmits a signal to the traffic signal controller that grants an extension of the green phase. Signal priority produces faster, more reliable transit service and reduced operational cost.

DART has considered the use of such systems but at this time they are not employed.

Intelligent Vehicle Initiatives

The FTA Intelligent Vehicle Initiative is designed to improve the safety of transportation services through the application of advanced vehicle technologies. The program focuses on the development, evaluation, and deployment of vehicle collision warning and driver information and assistance systems to reduce motor vehicle crashes. Current areas of transit research include: rear collision impact warning, frontal collision warning, side impact/lane change merge collision warning, pedestrian and passenger sensing systems, precision maneuvering and docking systems, and human factors associated with driver-vehicle interfaces. Recent research estimates significant benefits in avoidance of injuries, fatalities, and property damage from such technology.

DART has not pursued this area as yet.

Review of APTS Implementation and Benefits In Other Parts Of The Country

Included in this study was work focused on determining how costs and benefits of advanced transportation initiatives were evaluated for transit agencies across the country. This background information was considered as an evaluation of the DART First State AVL/GPS project was conducted. Much of material in this section is from “Benefits Assessment of Advanced Public Transportation System Technologies – Update 2000” that was built upon prior work by the Volpe Center and other agencies for the FTA under the APTS Program.

This section will provide a quick overview of what was learned in researching other efforts. A more complete discussion is available in the appendix of this report and includes references to specific transit agencies.

Benefits Assessments of APTS

Fleet Management Systems

Fleet Management Systems involve the integration of fleet based communication, automatic passenger counting, vehicle monitoring/location, and vehicle control technologies to improve the overall planning, scheduling, and operations of transit systems. Primary benefits of fleet management systems include increased safety and security, improved operating efficiency, improved quality of service, and improved customer information systems.

Many transit agencies have reported reductions in emergency response times of up to 40%. Many agencies reported the benefit of having the location of transit vehicles in order to respond to accidents, crimes, or other situations that warrant quick response time. The ability to monitor vehicle movements and to respond to silent alarms has increased the sense of transit security and improved the response to emergencies and incidents. Preliminary results have shown reductions in overall transit fleet requirements and non-revenue service time and mileage. Transit agencies have reported reductions in fleet requirements ranging from 2% to 5% as a result of efficiencies in fleet utilization. Many deployments of AVM/AVL have demonstrated improvements in overall schedule adherence. In a benefit analysis based on the estimated reduced transit fleet operating costs for all deployments in the country over a 10 year period, the most likely estimated benefit for fleet management systems was \$1.2 billion. Ninety percent of this benefit was expected by fixed route deployments. AVM/AVL deployments are being used to develop tighter more efficient schedules and to reduce the time and costs associated with conducting route schedule adherence checks.

In a study conducted in 1994, National Urban Transit Institute investigated the benefit and economic feasibility of AVL and communications systems for bus transit. This study

conducted a break-even analysis to determine the feasibility of cost recovery of AVL deployments based on savings as a result of reductions in schedule slack time and fleet reductions and found that in order for a representative transit agency to recover its fleet management system investment costs it must reduce its fleet size by 2.3% or reduce its revenue miles by nearly 1%. The same savings could be achieved with a 2.3% increase in revenues or 2.3% increase in transit ridership.

A review of over 800 APTS deployments across the country found that the projected benefits for all APTS technology in operational to planned stages would range from as low as \$3.9 billion to as high as \$9.6 billion through the years 2000 to 2010, with the most likely estimate being \$6.7 billion. For the study's most likely estimate, the deployments of APTS electronic fare payment systems represent nearly 35% of the total projected benefits, while deployments of advanced traveler information systems account for 25% of the benefits. Fleet management systems represented 18% of the benefits, and the deployment of operational software and computer aided dispatching systems represent 10% of the benefit. Intelligent Vehicle Initiatives were estimated to be 12% of the benefits.

Operational Software and Computer Aided Dispatching Systems

Operational software and computer aided dispatching systems are being expanded to automate, streamline and integrate many transit functions and modes. Systems are being used for transit service and route planning, for monitoring and control of transit operations, and for providing more accurate information of transit demand and ridership trends. When linked with AVL systems, operational software systems provide real-time dispatching of transit service, faster responses to service disruptions, and improved coordination of service of various transit modes. For demand responsive transit operations the applications of operational software and computer aided dispatching systems are being directed to improve the operations of small urban and rural transit systems and improve the services to many groups of citizens that require specialized transportation services not readily available by fixed route bus.

The scheduling of demand responsive services is highly complex because of the shared-ride nature of the trips, the special needs of the passengers, and the constraints under which agencies must comply to provide services. It entails the recording and scheduling of incoming passenger reservations for on demand, real time trips or on advance reservations for trips to be taken the next day, week, or month. Passengers, vehicles, and , in some cases drivers, are scheduled based upon the types of service required, time/day of week, and locale of trip origins and destinations. The vehicle routes and schedules are optimized by minimizing travel time or distance subject to the constraints of vehicle capacity and passenger desired pickup and drop-off times.

Operational software and computer aided dispatch systems can improve the efficiency of transit operations through more efficient scheduling of transit resources. References to some applications indicate reduction in vehicle miles, increases in shared rides, decreases

in cost per passenger trip, and decreases in operating costs per mile. For fixed route bus, operational software systems help maintain transit schedule adherence and coordinated transfers to minimize the wait time for transferring passengers.

Advanced Traveler Information Systems

Itinerary planning systems allow passengers to plan trips using one or more available transit services. These systems are directed to those transit passengers (tourists, visitors) who are making one-time trips or who are less familiar with available transportation services. Real time information systems provide transit patrons with up-to-date information on scheduled transit vehicle arrival times, delays of routes, service disruptions, and re-routings. Generally this information is provided to transit riders through in-vehicle, bus stop or terminal display systems, automated telephone messaging systems, cable television, and through internet web sites. Transit accessibility systems are directed towards providing improved transit information to passengers with disabilities, and include “talking signs”, “talking kiosks”, telephone information systems, and in-vehicle enunciators.

There are many major deployments of advanced traveler information systems across the country many of which are integrated with other APTS technologies like AVL. The primary benefits in terms of dollars are in the form of increased transit ridership and transit revenues from passenger fares. Advanced traveler information systems have been found to be effective in promoting transit services to current and potential new transit patrons. Applications of advanced traveler information systems provide a more convenient and potentially lower cost alternative for disseminating traveler information as compared to published transit schedules and telephone information systems.

Advanced Public Transportation Systems Program: Evaluation Guidelines

Having reviewed the technology initiatives at DART and having described benefits and references to national initiatives, the goal of this project is to develop a methodology for examining benefits for DART First State. This project proceeded with national guidelines for evaluating APTS as prescribed by “APTS Evaluation Guidelines” (Advanced Public Transportation Systems, Technical Assistance Brief 2, U.S. DOT, Federal Transit Administration, Office of Technical Assistance and Safety, Summer 1993.) This document is provided in the appendix of this report.

The Advanced Public Transportation Systems (APTS) Program was established by the Federal Transit Administration (FTA) as part of the overall USDOT Intelligent Vehicle Highway Systems Initiative. As part of this program local initiatives and APTS sponsored operational test will be documented through evaluation plans developed from comprehensive national guidelines to assure compatible data sets. Technologies covered under this program include AVL, smart card systems, dynamic ride share systems, passenger information systems, and vehicle monitoring systems. APTS project evaluations should be subject to common guidelines and will focus on examining the effectiveness of APTS applications in real world environments in terms of factors such as costs, benefits, and market response. Projects will be assessed on the success in meeting basic objectives such as enhancing the quality of transit service to customers, improving system productivity, and meeting community goals.

The evaluation process as outlined consists of four major phases:

- the evaluation frame of reference
- evaluation planning
- evaluation implementation and
- potential evaluation spin-offs.

The evaluation frame of reference establishes the background and description of (1) the operational test; (2) the APTS Program objectives; (3) local objectives, issues, and site characteristics; and (4) potential external influences.

The evaluation planning phase develops a detailed, structured plan for conducting the evaluation and contains measures, data collection sources and requirements, and analysis/derivation techniques needed to properly assess the costs, functional characteristics, efficiency, effectiveness, and other impacts of the equipment or service to be implemented.

Each detailed evaluation plan will contain a listing of relevant measures to be considered. The measures have been organized into performance categories. These categories are: financial impacts, functional characteristics, user acceptance, transit system efficiency and effectiveness, and other impacts.

The Advanced Public Transportation Systems (APTS) Program Evaluation Guidelines, as promoted by the Federal Transit Administration, describe impacts that should be addressed as shown in Figure 1, below. A full evaluation of the APTS as described by the Guidelines perhaps involves a much more detailed study of impacts and benefits than this project would allow, but there was an effort in this project to conduct the work in accordance to the guidelines.

Figure 1, An Organization of Impact Measures

About the Technology and Implementation (costs)

Financial Impacts

- Costs of implementation and fixed costs
- Costs of operation and on-going costs, maintenance
- Other Related costs, marketing, administration,

Functional Characteristics of the technologies

- Accuracy of technology
- Reliability
- Maintainability
- Adherence to specifications
- Personnel issues / human factor

Benefits Measures

Measures of efficiency

- Vehicle usage measures
- Operation statistics
- Personnel time
- Fuel
- Vehicle maintenance

Measures of effectiveness

- Revenue
- Costs
- Service Utilization
- Service Reliability and quality
- Customer service/satisfaction
- Incident Management
- Safety
- Security
- Impacts on capital resources/investments

Other Impacts

- Personnel and organizational concerns
- Response to national mandates
- Capacity for growing demand
- Community goals
- Traffic congestion mitigation
- Types of service offered
- Others

Evaluation Framework

A specification of the context and background of transit service in Delaware is necessary for beginning the evaluation. Various trends such as the demand for public transportation now and in the future need to be considered. For this study the evaluation framework addressed the following:

- Goals of technology implementation
- Demand for Transit, trends
- Recent changes in service, population served, service area
- Compliance with Federal(e.g. ADA, Clean Air Act and State (e.g. 800MHZ) initiatives
- Changes expected in the future

Other considerations unrelated to technologies that need to be taken into account when examining measures and evaluating costs and benefits.

Goals of the Evaluation

In many areas of operation and customer service many benefits can be sited. Given the large investments in the technology, the Delaware Transit Corporation (DTC) would like a comprehensive, detailed study and presentation of the costs and benefits. Benefits need to be quantified. DTC would like to have a clearer picture of how technologies support their current and future goals.

Objectives of AVL/CAD Implementation From the Literature

In a survey of 29 transit agencies across the country who implemented AVL technologies, the majority identified schedule adherence as their number one objective. (AVL Systems for Bus Transit – A Synthesis of Transit Practice, TCRP Synthesis 24, Federal Transit Administration, Transportation Research Board, National Research Council)

Figure 2, Objectives of AVL Implementation, Nationally

Objective	Percent Responding
Schedule Adherence	56%
Safety and Security	48%
Performance Monitoring	40%
Public Information	40%
Improved Communication	20%
Improved Fleet Management	20%
Improved Data Management	8%

As stated in Delaware Transit Corporation's (DTC) FY 2001 – FY2003 Strategic Plan, the mission of the agency is “to design and provide the highest quality transportation services that satisfy the needs of the customer and the community.” Key objectives of DTIC are, among others, to:

- Increase ridership in support of the department's Long-Range Transportation Plan.
- Improve the quality of services provided to customers
- Improve the cost effectiveness of transit services the DTC provides to customers
- Increase the effectiveness and awareness of Safety and Security for all customers, employees, and the general public.

Meeting these objectives are the higher level agency reasons that have been cited for implementation of new technologies and there have certainly been benefits realized along these lines. Performance measures related to transit usage, fleet maintenance, and operational efficiency are some of the areas where progress can be quantified, but the strong emphasis that DTC places on the quality of transportation services also requires the consideration of less easily measured benefits such as passenger convenience, and the general flexibility and responsiveness that results from much improved capabilities in information collection and management that new systems have to offer overall.

Goals of APTS at DART

In developing an approach to examining the costs and benefits for the implementation of AVL/CAD technology it quickly became apparent that an evaluation organization was needed to view the various higher level goals, objectives, and measures of success.

The primary goals of DART First State APTS Implementation are:

- To improve communications with transit operators toward better response, and improved dispatching
- To have the ability to track the locations of transit vehicles in real time towards better dispatching and improved customer service
- Through gains in efficiency, address growing demand for services without adding additional personnel or equipment. Improve quality of service.
- Improve convenience for transit customers and improve visibility of transit services thru the implementation of real time passenger information systems.
- To have the ability to track the location of transit vehicles in real time towards better planning.
- Improve safety, emergency response, and incident management.
- Increase ridership in support of the department's Long Range Transportation Plan.
- Improve handling of complaints and disputes among the public, operators, and management.
- Through use of technology realize cost and quality benefits in regards to maintenance of transit vehicles.

- Provide a more accessible, responsive, and efficient transportation system by using capital funds to reduce long term operating expenses.
- Provide more effective management and accountability.

Trends and the Demand For Services

One argument for pursuing automation in operations and advanced information systems is that they will provide greater efficiency in operations to an extent that services will be provided at a substantially lower cost. Not considering the improvements in the quality of service, to the extent that it can be shown that changes will realize cost savings in the short or long term, spending on new technologies can be justified. There is an expectation that if the technology is cost effective, that perhaps less personnel will be needed, less vehicles will be needed, that some savings will be realized, so that operating costs will be lower.

DART First State however has seen a significant increase in the demand for services. Transit ridership overall has increased by 10 to 15%. Ten years ago DART was providing 500 para-transit trips per day and today in 2003 is providing 3000 trips per day. The agency employed 4 paratransit schedulers when there were 500 trips and with 3000 trips there still are only 4 schedulers handling a 6 fold increase in demand. So in this area, either DART is working harder or smarter or both.

In examining the total costs before and after implementation of AVL and related technologies, its necessary to consider how demands have changed and the nature of services provided have changed, and the changes that are expected in the future. Figures 3 and 4 below show the documented and expected demands for transit service.

Figure 3, Ridership Trends in Paratransit

	FY96	FY97	FY98	FY99	FY00	FY01
NCC	150,328	180,233	198,012	230,439	269,068	297,200
KC	91,671	103,269	111,524	120,149	132,675	140,289
SC	47,186	51,800	62,746	77,990	88,537	103,621
Total	289,185	335,302	372,282	428,578	490,280	541,110
%INC		16	11	15	14	10

	FY02	FY03	FY04	FY05	FY06
NC	312,722	321,347	363,488	389,491	415,494
KC	127,660	129,140	140,234	144,987	149,740
SC	113,578	111,436	131,957	143,061	154,165
Total	553,960	561,923	635,679	677,539	719,400
%INC	2	1	13	7	6

	FY07	FY08	FY09	FY10
NC	441,497	467,500	493,503	519,506
KC	154,494	159,247	164,001	168,754
SC	165,269	176,374	187,478	198,582
Total	761,260	803,121	844,982	886,842
%INC	6	5	5	5

Figure 4, Trends in Ridership, Fixed Route

YEAR	NCFIXED	KCFIXED	SCFIXED	SEPTAR2	InterCnty	5310
1999	6,948,982	312,639	271,053	641,441	79,390	0
2000	7,226,941	377,856	274,248	661,326	83,360	1,750
2001	7,516,019	407,893	277,496	681,166	87,527	5,250
2002	7,816,650	422,893	280,795	701,601	91,903	15,750
2003	8,129,315	437,893	284,148	722,649	96,499	47,250
99to03	16%	40%	5%	12.5%	21%	

17% fixed route increase from 1999 to 2003

DART First State Resources and Current Budgets

As is indicated above, ridership on the paratransit service is increasing much faster than ridership on fixed route. Based on this, DART First State will spend a greater percentage of the budget on paratransit than ever before. Due to this significant increase in spending, it is essential that DTC become more creative in dealing with excess demand and managing growth.

Other Changes expected In The Future

The largest population growth area within the State of Delaware is that of Sussex County. As more and more baby boomers retire to the Resort area, the need for services for the elderly and disabled is also growing. This has and will continue to put a tremendous burden on DART First State Resources. The problem will not be solved overnight and as such, better management tools are required to improve efficiency and service to this population segment.

Compliance with Regulations (ADA) and Other State Initiatives

Delaware continues to exceed the requirements of the Americans with Disabilities Act by providing complementary paratransit service anywhere within the State boundaries. This has resulted in significant growth that has exceeded budget expectations. Continuing to operate beyond Federal Regulations will only exacerbate the problem of growing demand.

Evaluation Plan

Evaluation of Costs and Impacts

Figure 5 below shows a general outline of what will be considered in terms of costs and impacts.

Figure 5, Financial/Organizational Impacts

Costs of implementation and fixed costs
Costs of operation and on-going costs, maintenance
Other Related costs, marketing, administration,
Functional Characteristics of the technologies
 Accuracy of technology
 Reliability
 Maintainability
 Adherence to specifications
 Personnel issues / human factor

Evaluating Benefits

National APTS guidelines and references in the literature about the benefits of APTS implementation have often been organized around categories of the technology such as:

- Fleet Management Systems
- Operational Software and Computer Aided Dispatching Systems
- Advanced Traveler Information Systems
- Electronic Fare Payment Systems
- Intelligent Vehicle Initiative

While these categories are very useful as an organization for discussing the technology, it was determined, that a more appropriate organization for cost/benefit analysis would be one focused on the goals initially envisioned for the implementation. The success of the implementation and view of benefits and costs are focused around how goals are achieved.

From discussions with DART personnel and an examination of the literature, the following indicators were examined corresponding to goals for the implementation of the technology.

- **Improve Communications With Transit Operators Toward Better Response, and Improved Dispatching**

Indicators of success:

- Improved schedule adherence
- Better incident management and adjustments to weather conditions
- Facilitated on-street service adjustments
- Reduce passenger travel times
- Enhance response to vehicle and facility failures
- Improve communications with users having disabilities and meet their needs.
- References to incidents handled/avoided
- On-time performance
- Reduce paratransit wait times

- **To Have The Ability To Track The Location Of Transit Vehicles in Real Time Towards Better Dispatching and Improved Customer Service**

Indicators of success:

- Improved schedule adherence
- Reduction in schedule slack time
- Improved transfer coordination
- Effective tracking of off-route buses
- Less need for road supervisors
- Increased accuracy in schedule adherence monitoring and reporting
- Facilitated on-street service adjustments
- Monitored driver performance
- Reduce passenger travel times
- Enhance response to vehicle and facility failures
- Reduce transit system costs
- Handle increased paratransit demand without new personnel, efficiency gains
- Better informed public from real time passenger information
- Decreased cost per trip
- Reduced non-revenue dead head times
- Reduced fleet
- Trip miles versus average trip time
- On-time performance
- Reduced paratransit wait times
- References to effective incident management
- Reduced average emergency/incident response times
- Increased trips per vehicle hour
- Increased trips per vehicle mile
- Reduced costs per passenger trip
- Increased passengers per hour
- Evidence of improved customer convenience and satisfaction

- **Improve Convenience For Transit Customers and Improve Visibility of Transit Services Through the Implementation of Real Time Passenger Information Systems**

Indicators of success:

- Improved schedule adherence
- Improved transfer coordination
- Reduce passenger travel times
- Improve communications with users having disabilities and meet their needs.
- Enhance the mobility of users with ambulatory disabilities
- Substantially improve customer convenience
- Increased ridership
- Decreased customer wait time
- Greater facility to adjust to real time demands
- Better informed public
- Improved visibility of transit

- **Through use of technology realize cost and quality benefits in regards to maintenance of transit vehicles.**

Indicators of success:

- Decreased road calls
- Quicker response to break downs

- **Through gains in efficiency, address growing demand for services without adding additional personnel or equipment. Improve quality of service**

Indicators of success:

- Less need for road supervisors
- Reduced manual data entry
- Reduce transit system costs
- Maintain number of schedulers with increased demand
- Increase fleet size less in relation to increased demand
- Increase personnel less in relation to increased demand
- Reduce work stress and increase job satisfaction
- Reduction in schedule slack time
- Reduction in non-revenue dead head times
- Reduced cost per trip
- Increased trips per vehicle hour
- Increase trips per vehicle mile
- Longer lifetime of fleet, decreased maintenance costs
- Increased compliance with transit ADA requirements and other regulations
- Increased passengers per hour

- **Improve Handling of Complaints and Disputes Among Public, Operators, and Management**

Indicators of success:

- Protection against false claims and related litigation
- Effective tracking of paratransit vehicles and drivers
- Improved evidence gathering with location logs and surveillance history
- References to litigation avoided
- References to incidents handled/avoided
- Evidence of improved response to complaints
- Evidence of improved customer satisfaction
- Evidence of more informed analysis of complaints
- Monitored driver performance
- Decreased number of complaints
- Enhance opportunities for customer feedback

- **To Have The Ability To Track The Location Of Transit Vehicles in Real Time Towards Better Planning**

Indicators of success:

- Improve the usefulness of data for service planning and scheduling
- Increase the extent, scope and effectiveness of transportation demand management programs
- More easily track historical data and improve decision support systems
- Marketing improvements
- More appropriate and successful new service
- Increased ridership
- Decreases in data collection costs
- Improved data collection
- Improve the exchange of information within DelDOT and also with other transportation agencies

- **Improve Safety, Emergency Response and Incident Management**

Indicators of success:

- Effective use of evidence gathered with location logs and surveillance history
- Enhance response to vehicle and facility failures
- Apprehension of criminals
- Protection of passengers and operators
- Decreased number of incidents
- Protection against false claims and related litigation
- Better incident management and adjustments to weather conditions
- Decreased average emergency/incident response times
- References to incidents handled more effectively or avoided
- Evidence of surveillance as a deterrent
- Improved sense of safety of passengers
- Improved sense of safety of operators

- **Increase ridership in support of the department's Long-Range Transportation Plan.**

Indicators of success:

- Increased ridership
- Increased compliance with transit ADA requirements and other regulations
- Contribution to air quality goals.

- **Provide a more accessible, responsive, and efficient transportation system by using capital funds to reduce long term operating expenses.**

Indicators of success:

- Evidence of reduced operating cost while maintaining or improving the quality of service.
- Evidence of savings beyond the cost, replacement, and maintenance of the technology.

- **Provide more effective management and accountability.**

Indicators of success:

- Evidence of better decision making.
- Evidence of more effective management and involvement.
- Increased awareness of where money is spent.
- Evidence of increase productivity of managers.

Impact Measures: Technology and Implementation (Costs)

Initial Costs of AVL/CAD and upgraded communications

The information below provides data available on the costs of the APTS technology and communications. Because of the level of integration among the components it is fairly difficult to break costs in to the various areas such as “Fleet Management Systems” or “Operational Software and Computer Aided Dispatching Systems”. The upgraded radio systems were part of the compliance with State communications systems.

Figure 6, Approximate Initial Cost Breakdown For APTS At DART

Fixed Route Vehicle Equipment	1,966,676
On-demand Vehicle Equipment	1,366,889
Supervisor/avl Vehicle Equipment	138,538
Supervisor/Radio Vehicle Equipment	248,946
Service Vehicle Equipment	105,324
Portable Radios	299,322
Transportable Mobile Units	32,651
Demonstration CAD/AVL Unit	25,257
Base Radio Equipment	806,426
Microwave System	277,652
Spare Equipment	234,250
Dispatch Office Equipment	1,513,838
Garage Equipment	69,523
Software	323,649
Documentation and Training	214,552
Project Support	2,932,384
Fees and Other	108,481
Support/other items	1,081,838
Total	11,525,196

(includes about \$220,000 discount)

A portion of these costs were necessary as part of the conformance/conversion to the States upgraded radio communications system and would have had to been spent whether or not it was part of an integrated APTS system. This conversion is estimated to be in the neighborhood of \$5 million and this portion is not considered to be part of the APTS implementation, though its implementation is very integrated with the APTS.

There were additional upgrades and additions since:

- Advanced Traveler Information Systems about \$400,000
- Upgrade of cameras on buses including addition of audio about \$300,000
- Automated Passenger Counters, about \$400,000

The total APTS initial cost to date is estimated to be about \$7.6 million

Ongoing costs of APTS technology

There are 4 major ongoing costs associated with the technology:

- Hardware maintenance about \$150,000 per year
- On-going software support about \$150,000 per year
- One analyst/technical support position about \$70,000 per year
- Lifetime of systems expected to be 15 years. (Replacement costs of 800MHZ radio system is covered by the State with other funds.) As a rough estimate, using 1/15th each year of the total outlay (\$7.6 million) for a yearly replacement cost as a rough figure, that would be about \$500,000 per year.
- **Yearly costs including replacement estimated at about \$870,000.**

Functional Characteristics of the technology

There was a substantial training period to convert from pen and paper methods to computer systems, but personnel gradually became accustomed to the systems and now can't imagine how the agency did without it.

In implementation there were some delays primarily related to integration of software systems with GPS coordinates that were collected. APTS involved highly integrated systems to take advantage of all benefits. Most of these problems have now been worked out but certain phases of the implementation were slowed down.

The system is very reliable and does not breakdown or become non functional often. Accuracy of routing scenarios is dependable when making service changes. Dispatching personnel are very happy with it. The new systems are fairly easy to learn and dispatching personnel are particularly happy with the new technology.

The fleet management system was by Orbital Technologies, the Smart Track System that included mobile data terminals, vehicle sensors, and onboard cameras and audio. The operational software and computer aided dispatching was provided by the Trapeze system. Systems for advanced traveler information systems included the Next Bus system, Smart Bus, and Talking Sign.

Discussion of Benefits Realized By New Technology

This section of the report discusses and evaluates benefits of DART APTS technology in terms of benefits. The following pages are a discussion of benefits that were identified.

Goals

Below is a listing of primary goals for implementation of APTS technology. They are in no particular order. The discussion of benefits will reference relevant goals by the numbers below.

1) GOAL: Improved handling of complaints and disputes among public, operators, and management

TECHNOLOGY INVOLVED: On board cameras and audio, AVL Time/Location Playback, Audio and Video Playback.

2) GOAL: Improved safety, emergency response and incident management

TECHNOLOGY INVOLVED: On board cameras and audio, AVL Time/Location, Signage, Silent alarms.

3) GOAL: Improve convenience for transit customers and improve visibility of transit services thru the implementation of real time passenger information systems

TECHNOLOGY INVOLVED: AVL systems, Fleet Management Software, NextBus System.

4) GOAL: Through use of technology realize cost and quality benefits in regards to maintenance of transit vehicles.

TECHNOLOGY INVOLVED: AVL systems, engine heat sensors in buses, integration with maintenance information systems.

5) GOAL: Improve communications with transit operators toward better response, and improved dispatching

TECHNOLOGY INVOLVED: Remote data terminals, emergency audio, silent alarms.

6) GOAL: To have the ability to track the location of transit vehicles in real time towards better dispatching and improved customer service.

TECHNOLOGY INVOLVED: AVL Tracking Systems, Fleet Management Computer Systems

7) GOAL: Through gains in efficiency, address growing demand for services without adding additional personnel or equipment. Improve quality of service.

TECHNOLOGY INVOLVED: Dispatching software, models of transit networks, geocoding capabilities.

8) GOAL: To have the ability to track the location of transit vehicles in real time towards better planning.

TECHNOLOGY INVOLVED: AVL Tracking Systems, Fleet Management Computer Systems, Automatic Passenger Counters, Trapeze Software.

9) GOAL: Develop capabilities to work smarter for more efficient, safe, high quality operations.

TECHNOLOGY INVOLVED: Highly dependent on software capabilities but resulting from an integration of all technologies.

10) Goal: Provide a more accessible, responsive, and efficient transportation system by using capital funds to reduce long term operating expenses.

TECHNOLOGY INVOLVED: AVL Tracking Systems, Fleet Management Computer Systems, Automatic Passenger Counters, Trapeze Software.

11) Goal: Provide more effective management and accountability.

TECHNOLOGY INVOLVED: AVL Tracking Systems, Fleet Management Computer Systems, Automatic Passenger Counters, Trapeze Software.

Benefits Identified

- Communications have vastly improved. A reliable communication system is in place that allows operators to immediately speak with management, and immediately provide on-board audio to management. Text messages and data can be transmitted to operators where it can be immediately viewed. Safety of drivers and passengers has improved. There is a great difference in communication.

Prior to implementation of voice and data terminals all communications were over an open channel. All conversations were audible to all operators and passengers. There could be dozens of operators simultaneously trying to use the one communication line and there was a great deal of confusion. In the event of an emergency it could be very difficult to get through, and there were no covert ways of communicating or getting assistance. Dispatchers had to continually handle many conversations at one time. Handling the microphone was difficult.

With the new technology a button is pushed to request communication. Management personnel can view, cue, and prioritize requests for contact. Operators no longer have difficulty contacting the operations office in the event of an emergency incident. Silent alarms are located near the driver's seat. All communications are recorded and can be played back at any time. This playback feature is used on almost a daily basis by managers to review communications for any problems and to address employee issues. Managers can listen to a whole day's worth of communication while at their desks. A vast amount of information is available to managers to examine and improve operations. Text messages and other data such as scheduled runs and information about customers can be sent to remote terminals on the vehicles at any time. By sending information directly to remote terminals, operators don't have to waste time copying down information or returning to the yard to pick up another manifest. All information is sent directly to vehicle operators. (Goals: 1,2,5,7)

- Examination of operating statistics between the years 1996 thru 2004 indicated that the number of paratransit trips had increased by about 85% while the number of vehicles used went up 60% indicating more efficient use of vehicles. Trips per hour for paratransit has stayed fairly constant through these years, averaging roughly 1.8 trips per hour. It was expected that with more efficient routing trips per hour would increase. The fact that it appears to have stayed the same may still indicate greater efficiency as average trip distances have increased in the neighborhood of 10 to 15% with increased suburbanization and with DART increasingly serving lower density areas particularly in Kent County. Total costs per vehicle mile for paratransit have remained the same between the years 1998 and 2004, at \$2.29 per vehicle mile. (Goals: 7, 10)
- Total maintenance staff for North and South Districts, for paratransit and fixed route vehicles, was 89 persons in the year 2000. Through the year 2004 it

appears from the data that only 1 service technician, 1 assistant auto technician, and 3 apprentices have been added. During those five years, vehicle miles increased about 20% in those 5 years, and the number of vehicles increased about 9% with only about a 3% increase in staff. Better yet, road calls per 100,000 miles have been on the decline since 1999, from about 25 calls to 15. Average miles between road calls in FY'03 was 2,086 miles. In FY '04, average miles between road calls was 3,489 miles, a very significant improvement, saving large amounts of staff time and inconvenience to the customer. DART personnel attribute this to an improved ability to better manage and dispatch the fleet, allowing maintenance activity to be spread out and improving maintenance personnel productivity with almost no changes in the number of personnel. (Goal 4)

- DART estimated that because of more efficient operation and better utilization of vehicles, the purchase of 6 additional vehicles was unnecessary and this translated to a savings of about \$25,000 per year. (Goal 10)
- There is a substantial capability to track the location of transit vehicles in real time towards better dispatching, improved customer service, and more efficient use of resources. Rather than relying on the drivers and communications with many drivers, operations personnel view the exact location of all vehicles (fixed route and paratransit) and make intelligent dispatching decisions to improve service and efficiency in real time. Paratransit routes can be planned each day with reliable estimates of run times. The public frequently contacts DART to find out when a vehicle will arrive and the automated system provides quick and accurate answers. Previously as requests for service were issued on a day to day basis, dispatchers had to contact vehicle operators to determine their location, adherence to schedule, and ability to alter currently scheduled runs to accommodate demand as it arose. The whole system relied a great deal on trust and was hard to manage. Now all decisions can be made by dispatchers with a real time view of how best to serve customers. Systems can provide a very accurate estimate of what changes can be accommodated by drivers. (Goals: 5, 6, 11)
- The growing demand for services has been addressed with much less additional personnel or equipment. Quality of service has increased. With the improved dispatching software, management can now examine various scenarios for daily paratransit runs and can much more easily construct strategies to efficiently serve customers and can accurately predict travel and boarding times to insure that service is on time and most efficient. Features of the software can also factor in various amenities needed for developing daily runs such as wheel chair access, and can align runs to service guidelines such as maximum passenger travel times and accessibility needs. Close to 3500 paratransit trips a day in Delaware are served currently when in years past there were close to 500. This demand is being served with no increase in the

number of schedulers (4) over the years. With the exception of an analyst position, there have been no additional operations personnel added in the last 3 years. Overtime hours of vehicle operators have been reduced substantially. In years past scheduling even 200 paratransit trips a day was a daunting task and was very labor intensive and relied on difficult tasks of examining hard copy records. While in many cases paratransit service to suburban and rural areas is not required by law since there is no transit service currently provided in these areas, it is a general policy of the State legislature to provide transportation in these areas, particularly for elderly populations and those who are not eligible under ADA. This has led to an ever increasing demand for transit service that could not be provided using older methods.

Implementation of the Hybrid System for Kent and Sussex to better serve the suburban/rural population was greatly supported by new technology, where now passenger's per hour is at about 3 where before the service was implemented, passengers per hour was measured at 2.1 which is a huge improvement. Fifty percent of paratransit are planned, regular trips that are known before schedules are being developed. The remaining 50% are "casual" trips the can not be so easily predicted and planned for. The new software keeps a detailed history of transit trips, their type, their location and other information that enables schedulers to estimate the staff needed for each shift based on historical demand when preparing work blocks for vehicle operators to bid on. By being better able to predict demand, the amount of time more staff is needed than predicted (overtime costs) and the amount of time where staff are not fully utilized, can be minimized. (Goals: 7, 10, 11)

- The ability to track vehicles in real time and track all historic operations data has greatly contributed to better planning. In place of costly on-board surveys that provide only a snapshot of ridership on a particular day, automatic passenger counters can record boardings and alightings at each transit stop and can get a continuous view of ridership throughout the year. Federal reporting is facilitated. Strategies to improve service can be developed and examined with a large amount of information prior to implementation. Managers can now better use their time in improving service and efficiency and software systems offer numerous statistics and reports to gauge problems and find solutions. Markets for transit can now be much better analyzed and the progress of current and new service monitored effectively. (Goal:8, 11)
- The ability to handle complaints and disputes among the public, operators, and/or management have vastly improved . Management knows where vehicles are at all times and can review history. Customer complaints can be handled in a much more informed way. All communications can be monitored and played back at a later time. Legitimate complaints and areas where improvement are needed can be identified and acted upon with the appropriate information being available. While monitoring and recording systems have sometimes gotten a rap as "big brother" tools, they benefit employees as well as management. Many disagreements that previously could not be assessed

because it was one person's word against another can be addressed by playing back communications between drivers and dispatchers, or viewing the AVL location log. Union disputes are more easily addressed. In times before the technology was implemented, the entire system was based on trusting the word of the operator on their whereabouts, and their capability to respond to runs in the field. When a customer complains about a transit vehicle not being on time or being absent, or not stopping for them, location logs and video can be (and are) reviewed. Any type of inappropriate behavior by operators is greatly discouraged when locations of vehicles and monitoring equipment is in place. (Goals: 1, 2)

- There is significantly improved safety, emergency response, and incident management. Operators have used the technology on almost a monthly basis where their safety was at stake, in sometimes dire situations. Cases have occurred where a driver has been shot or stabbed and the system helped respond to the situation. About 10 arrests a year of passengers committing robbery, assault and other crimes have resulted. Last year, a rapist has been apprehended thanks to the system. The safety of operators and the public is very significantly improved.

Operators can easily alert operations personnel and push a silent alarm, any time there is trouble. On board video cameras and microphones can record any incident and broadcast events in real time to the operations center. The AVL system can accurately pin point the location of the bus for quick response of public safety personnel. Bus drivers can indicate to passengers that they are being recorded to head off serious incidents before they occur. Signs over the bus can signal to the public that there is a problem on the bus and to call for help. Criminals who have used buses for transportation or have preyed on passengers have been apprehended with the use of video systems. In cases where accidents have occurred (about 8 serious accidents a year), video taken toward the front of the bus has proven the bus driver not at fault in a few situations avoiding costly litigation and liability. In one case a person losing a leg in the accident was shown to have walked in front of the bus, when the original charge was that the driver was at fault. Massive savings appear to be realized in worker compensation claims. Before onboard video and audio equipment was put in place in 2001 costs for work's compensation were around \$1.2 million a year. The following year costs were in the neighborhood of \$200,000 and claims were cut in half. It appears that audio and video data used in reviewing cases discourages and minimizes claims. In terms of costs for auto liability including injury or property losses, it is expected that video from out of the front of the bus and within would achieve some savings in false claims and settlements were there was no such evidence. Looking at incurred costs from vehicle accidents over the last couple years may show some savings perhaps in the \$500,000 range, but costs vary from year to year, and cases take a few years to close so more time and data is necessary to see a trend. (Goal: 2,9, 10, 11)

- There is improved convenience for transit customers and improved visibility of transit services thru the implementation of real time passenger information systems. Dispatchers and customer service personnel can now provide reliable estimates of when transit vehicles will arrive at various stops in the system. Real time electronic display message boards using data taken from satellite tracking systems can take into account the actual position of the buses on routes, their next stops, and known traffic patterns to arrive at continuously updated estimates of bus arrival times.
Shelters equipped with these message boards also advertise service at that location. These message boards have been used at Delaware Resort areas and have contributed to a 13% increase in Resort Service ridership. Often passengers arrive at a bus stop wondering at the expected time of arrival. When an accurate display of arrival time is posted, passengers may feel free to relax or use the time in some way if the bus will not arrive for several minutes. Where buses are not tied to a fixed schedule but are in a continuous looping pattern (i.e. typically one every half hour) this makes waiting for a bus much easier. (Goals: 3,6)
- On time performance has improved. On time performance figures have shown improvement over the years with about a 2 or 3 % average increase. What must be also considered is that these measurements have a lot to do with how the information is collected. With the introduction of AVL there is currently a 10 to 20% random sample of routes. Previously there was only a 2% sample that was not random, time checks were done whenever the street supervisors could get to it. Therefore previously there was a bias toward less busy times, and times when there wasn't a problem in the system. It's generally recognized in the industry that when the sample size increases and samples are truly taken randomly, on-time performance measures are significantly worse. Once AVL was implemented and on-time performance was measured randomly and the sample increased, on-time performance measures were slightly better. Operators have felt fairly certain that on-time performance was improved with AVL, and the fact that the numbers didn't decrease with better measurements is an indication that on time performance has increased even more than the numbers reflect since the introduction of new technologies. (Goals: 6,7,9, 10)
- There are other considerations with on time performance numbers. With paratransit, if a customer is in the bus for more than an hour, the trip is not considered on time, even if it's a minute late. But there are a number of long trips that are conducted that because of distance can involve close to an hour travel time. Another measure used, "on time for paratransit pickup", has improved greatly. Whether the paratransit operators were on time for the pick up is considered a better measure of service. If passengers can depend on the time they will be picked up then the service is much better, they are not as anxious and are not calling into operations as much (using more staff time to track the trip down and get back to the customer). Slight deviations from

arrival time to the destination are not as much an issue as long as the client is in route and they are on time. Pickup on time was estimated to be around 65 to 70% on time prior to AVL and scheduling technology, and now are estimated at around 90%. This is a very big improvement. (Goals: 3,6,7)

- Dart First State has considerably more information to determine how and where money is spent. There is a substantially increased ability to examine numerous operational scenarios to determine what operational changes may be worth. There are numerous cases where knowing the cost impacts of proposed changes and generally where money is going is a huge advantage. In one example in labor negotiations, the transit company had a good hunch that a slight change in how runs were created and compensated could lead to significant yearly savings. Labor desired changes in benefits. The AVL and scheduling systems were able to calculate fairly accurately the cost and benefits of operations changes. DART was able to understand what various changes would be worth and realized that with some of that savings they could offer increased benefits to employees making for a very informed negotiations where both parties benefited. Just this one example is expected to save DART about \$60,000 per year every year. Changes in how things are done can involve a great deal of effort and can have complicated impacts. Intelligent systems that can track and estimate costs of service and examine complicated scenarios can save lots of money and use resources much more effectively. In prior years operational trends were more difficult to identify. If costs increased, additional funds were obtained or budgets altered but there was not as much information available on which to base decisions on. (Goal 9, 11)
- There are clear measurements of increased efficiency. Before Trapeze and AVL, the “Pay to Platform” ratio was around 1.2. In Dec of 2003 it was measured at around 1.14. That represents about a 6% improvement. From estimates in total expenditures for personnel, this represents freeing up salary costs in the neighborhood of \$600,000 per year. In the same time period, DART was paying much less overtime and spread costs for salaries. Average scheduled overtime premium time went down about 7%, and average scheduled spread premium dropped in the neighborhood of 20%. With more efficient use of the time, the work force was not reduced but during that time an additional route was added (Route 7) with no additional drivers hired and no additional vehicles needed. (Goals: 6,9, 10, 11)

Benefits Quantified

Of course, some benefits are difficult to quantify but an attempt here is made to reference figures that can be, to at least to provide a rough comparison with costs to see if the investment has paid off.

- On board video cameras and other monitoring systems provide information that is needed to prevent massive losses in man hours, large legal fees, settlements, and liabilities. An incident was identified in this investigation where a pedestrian lost a leg in an accident and was seeking damages saying it was the DART bus operators fault when the video clearly showed that DART was not at fault. Accidents are not uncommon nor are false claims. A very conservative estimate is guessed at this kind of capability being worth \$500,000 a year. As a side note, incidents avoided or managed by employing surveillance and location systems before they get out of hand, are hard to quantify, but a well publicized case of a passenger being attacked on a bus could discount huge promotional investments to get the public to use transit more. There has got to be a feeling of safety on the system.
- Workman's compensation costs seem to have experienced a drastic decline with the introduction of video and audio on the buses. Year 2003 figures one year after the introduction of full audio and video on the buses, indicates perhaps a decrease in costs by as much as \$1million per year.
- References were made previously to reductions in the pay to platform hour ratio. This decrease is estimated to be worth about \$600,000 in salary time a year and is expected to be realized year after year. That doesn't include other reductions in overtime and premium split shift time.
- DART estimated that because of more efficient operation and better utilization of vehicles, the purchase of 6 additional vehicles was unnecessary and this translated to a savings of about \$25,000 per year.
- Systems have provided DART the ability to understand what operational or policy changes are worth. In one reference to a labor negotiation, DART is expected to gain \$60,000 per year in arrangements directly attributable to DART having a better understanding of operational costs.
- Costs to hire contractors to periodically monitor ridership can be saved and the data is far superior. Costs saved are expected to be in the neighborhood of \$25,000 per year.
- Schedulers were planning and scheduling about 500 paratransit trips per day and now the figure is over 3 thousand trips per day. No new schedulers have been hired through this increase, there still are four. Before dispatching and scheduling software was in place preparing each days paratransit schedules was extremely difficult. As a conservative estimate perhaps it would have taken at least twice as many schedulers to accomplish the daily task. Assuming about \$50,000 per employee including benefits and overhead, that would be about \$200,000 per year in savings. But really it may have taken more schedulers and the type of refinement that can now take place with

schedules to accommodate specific passenger needs would probably not be practically possible.

Costs Versus Benefits

Initial startup costs for all APTS hardware, software, and installation cost about \$7.5 million. Ongoing costs for new APTS technologies implemented at DART First State, including related personnel, maintenance and replacement of software and hardware is in the neighborhood of \$870,000 per year, where about a little of half of this is replacement cost.

Cost benefits in the form of personnel hours alone saved from decreases in pay to platform hours, and reduction in overtime and premium hours were estimated in the neighborhood of \$600,000 per year. Savings in workman's compensation costs could be close to \$1million per year. Other cost savings identified in the previous section are in the neighborhood of over \$700,000 per year. Rough estimates in cost benefits of the technology are then about \$2.3 million a year.

If one simply focuses on the costs and benefits that can be associated with numbers, yearly benefits would outweigh yearly costs. With an estimated \$7.6 million initial outlay for the technology (80% federal, 20% state), the initial costs could even be recouped within about 5 years.

So the system certainly pays for itself where benefit figures can be identified. But there are huge benefits that are hard to put a number on like:

- Significantly improved safety for passengers and operators
- Significant improvements in the quality of service
- Increased ridership through advanced passenger information systems and a better product.
- The ability to handle greatly increased paratransit demand while improving quality of service.
- Better decision control and management capabilities
- Much more effective conflict resolution between management and labor.
- Much more effective and informed handling of complaints by the public

All of these benefits are very real and a result of the introduction of new technology at DART. With growing demand for services, particularly in the paratransit area, DART needed to get as efficient and productive as possible to avoid correspondingly higher costs. Benefits have been realized in the first few years of operation. One of the most important features of APTS technology is that it provides information for better management. Costs and policy impacts can be better estimated. Many changes made possible by a better understanding of operations have continued effects year after year and it is expected that additional savings will be realized each year as the agency has an improved knowledge of how resources are best used. Future needs and costs can be much better projected and understood so that better decisions and plans can be made now.

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1994, National Urban Transit Institute investigated the benefit and economic feasibility of AVL and communications systems for bus transit

APPENDIX A

Review Of APTS Implementation And Benefits In Other Parts Of The County

Review of AVL Implementation and Benefits In Other Parts Of The Country

Included in this study was work focused on determining how costs and benefits of advanced transportation initiatives were evaluated for transit agencies across the country. This background information was considered as an evaluation of DART First State AVL/GPS, while the project was conducted.

This section will provide an overview of what was learned in researching other efforts. A more complete discussion is available in the appendix of this report.

Benefits Assessments of APTS

Much of it is taken from “Benefits Assessment of Advanced Public Transportation System Technologies – Update 2000” that was built upon prior work by the Volpe Center and other agencies for the FTA under the APTS Program. The study addresses APTS in the following functional areas.

- Fleet Management Systems – involve the integration of fleet based communication, automatic passenger counting, vehicle monitoring/location, and vehicle control technologies to improve the overall planning, scheduling, and operations of transit systems.
- Operational Software and Computer Aided Dispatching Systems – automated systems designed to improve the effectiveness of transit scheduling, dispatching, service planning and operations.
- Advanced Traveler Information Systems- include a broad range of advanced computer and communication technologies designed to provide transit riders pre-trip and real-time information to make better informed decisions regarding their mode of travel, planned routes, and travel times.
- Electronic Fare Payment Systems – are advanced fare collection and fare media technologies, designed to make fare payment more convenient for transit users and fare collection more efficient and more flexible for the transit provider.
- Intelligent Vehicle Initiative – involves the development, evaluation, and deployment of advanced vehicle technologies, vehicle collision warning, and driver information systems to improve safety and efficiency of transit operations.

A review of over 800 APTS deployments across the country found that the projected benefits for all APTS technology in operational to planned stages would range from as low as \$3.9 billion to as high as \$9.6 billion through the years 2000 to 2010, with the most likely estimate being \$6.7 billion. For the study’s most likely estimate, the deployments of APTS electronic fare payment systems represent nearly 35% of the total projected benefits, while deployments of advanced traveler information systems account

for 25% of the benefits. Fleet management systems represented 18% of the benefits, and the deployment of operational software and computer aided dispatching systems represent 10% of the benefit. Intelligent Vehicle Initiatives were estimated to be 12% of the benefits.

Fleet Management System Benefits

Primary benefits of fleet management systems include:

- Increased Safety and Security – The ability to monitor vehicle movements and to respond to silent alarms has increased the sense of transit security and improved the response to emergencies and incidents. Many transit agencies have reported reductions in emergency response times of up to 40%. The Kansas City Area Transit Authority reported that with the implementation of AVL, emergency response times were reduced to 3 or 4 minutes from previous average response times from 7 to 15 minutes. Other agencies reported the benefit of having the location of transit vehicles in order to respond to accidents, crimes, or other situations that warrant quick response time. (Page 14)
- Improved operating efficiency – Most transit agencies incorporate layover times at the end of each trip, with the objective of preventing delays that develop in one trip from carrying over into the next trip. On average layovers can cause a vehicle to be in non-revenue service 20% to 25% of the time. By knowing the precise location of its vehicle fleet, transit dispatch centers can monitor and control fleet movements, reduce headway dispersion and platooning of vehicles, and reduce vehicle layover and non-revenue deadhead times. Preliminary results have shown reductions in overall transit fleet requirements and non-revenue service time and mileage. Transit agencies have reported reductions in fleet requirements ranging from 2% to 5% as a result of efficiencies in fleet utilization.
- Improved transit service – Management systems provide increased flexibility to monitor and control transit fleets and ensure adherence to published transit schedules. Many deployments of AVM/AVL have demonstrated improvements in overall schedule adherence. The Maryland Mass Transit Administration reported 23% improvement in on-time performance in a test of AVL equipped buses. With a 868 vehicle fleet the MTA expects savings of \$2 to \$3 million per year by purchasing, operating, and maintaining fewer vehicles. The Milwaukee Transit System installed AVL on all vehicles (543 buses and 60 support vehicles) and has reported that the number of off-schedule buses was reduced by 40% helping them to provide better and more reliable service to customers.
- Improved transit information – Many transit agencies are implementing AVM/AVL systems to provide information for their transit route planning and scheduling functions and their transit information systems. In Denver, Baltimore, Kansas City, and Seattle, AVM/AVL deployments are being used to develop tighter more efficient schedules and to reduce the time and costs associated with conducting route schedule adherence checks. Tri-County

Metropolitan Transportation District in Portland noted improvements in on-time performance, as well as reductions in headway variability, schedule variability, and excess customer wait time. Many transit systems are employing AVM/AVL to provide up-to-date schedule information to transit riders.

In a benefit analysis based on the estimated reduced transit fleet operating costs for all deployments in the country over a 10 year period, the most likely estimated benefit for fleet management systems was \$1.2 billion. Ninety percent of this benefit was expected by fixed route deployments.

In a study conducted in 1994, National Urban Transit Institute investigated the benefit and economic feasibility of AVL and communications systems for bus transit. This study conducted a break-even analysis to determine the feasibility of cost recovery of AVL deployments based on savings as a result of reductions in schedule slack time and fleet reductions and found that in order for a representative transit agency to recover its fleet management system investment costs it must reduce its fleet size by 2.3% or reduce its revenue miles by nearly 1%. The same savings could be achieved with a 2.3% increase in revenues or 2.3% increase in transit ridership.

Other references to benefits found in the literature include:

- Winston-Salem Transit Authority reports that their AVL CAD system has decreased paratransit passenger waiting time by 50%.
- There have been several instances in cities with AVL equipped buses where bus operators have observed accidents, crimes, or other situations which warrant quick response by emergency personnel. The AVL system's communication and location capability has allowed the emergency personnel to be quickly notified and directed to the exact location of the trouble.
- In Denver, a bus passenger had a seizure. The operator was able to notify emergency response personnel of the incident and its location and an ambulance was at the scene within eight minutes. Also in Denver, a man brandishing a knife was thought to have boarded a bus. Through the CAD/AVL system, the correct bus was identified, the police notified, and the man arrested. Customer complaints have fallen by 26% in Denver since AVL installation.
- Milwaukee County Transit System claims that on-time performance has improved from 90% to 94% after implementing their AVL system, even though the system is not fully operational.
- Transit operators claiming improved scheduling and schedule adherence after AVL implementation include: County of Lackawanna Transit System (Scranton Pa) , Broward County (FL) Division of Mass Transit, Beaver County (Rochester, PA) Transit Authority, Dallas Area Rapid Transit, Tidewater Transportation District Commission (Norfolk, VA), and KCTA.

- London Ontario's AVL system will provide schedule adherence on a continuing basis, thus saving the \$40,000 to \$50,000 previously spent on each schedule adherence survey.
- KCATA used AVL generated data to reduce scheduled running times in conjunction with a systemwide service reduction. It was estimated that the maintenance and operator cost savings from the schedule retiming would be about \$400,000 annually. Theoretically, this would result in a fleet reduction of seven buses with an attendant elimination of bus replacement costs of about \$225,000 per bus.
- Numerous transit authorities report easier resolution of customer complaints or a reduction in complaints including: Beaver County Transit Authority, Tidewater Transportation District, King County(Seattle) Metro, and Milwaukee County Transit System.

Operational Software and Computer Aided Dispatching Systems

Operational software and computer aided dispatching systems are being expanded to automate, streamline and integrate many transit functions and modes. Systems are being used for transit service and route planning, for monitoring and control of transit operations, and for providing more accurate information of transit demand and ridership trends. When linked with AVL systems, operational software systems provide real-time dispatching of transit service, faster responses to service disruptions, and improved coordination of service of various transit modes. For demand responsive transit operations the applications of operational software and computer aided dispatching systems are being directed to improve the operations of small urban and rural transit systems and improve the services to many groups of citizens that require specialized transportation services not readily available by fixed route bus. The scheduling of demand responsive services is highly complex because of the shared-ride nature of the trips, the special needs of the passengers, and the constraints under which agencies must comply to provide services. It entails the recording and scheduling of incoming passenger reservations for on demand, real time trips or on advance reservations for trips to be taken the next day, week, or month. Passengers, vehicles and , in some cases drivers are scheduled based upon the types of service required, time/day of week, and locale of trip origins and destinations. The vehicle routes and schedules are optimized by minimizing travel time or distance subject to the constraints of vehicle capacity and passenger desired pickup and drop-off times.

Operational Software and Computer Aided Dispatching Benefits include:

- Increased efficiency in transit operations – Operational software and computer aided dispatch systems can improve the efficiency of transit operations through more efficient scheduling of transit resources (vehicles and drivers) to passenger trip requests. In Santa Clara County, CA, a paratransit provider, OUTREACH, has completed a program to implement automated scheduling and dispatching system with a digital geographic database and a GPS based

AVL system. An evaluation of this system found that without automated trip scheduling OUTREACH would not have been able to accommodate the increases in the demand for paratransit services to meet full ADA compliance in 1997. The OUTREACH system was able to meet this demand by increasing the number of shared rides from 38% to 55% and reducing its fleet size from 200 to 130 vehicles, and these improvements in operations resulted in a savings of \$500,000 in the first year of service. The Winston-Salem Transit Authority (North Carolina) through its Trans-Aid division, installed a computer aided dispatching system to schedule DRT services for over 120,000 passenger trips per year and its fleet of 19 small buses. With the installation of the system in 1994, Trans-Aid showed an increase in ridership on its rural routes, a 12 % increase in its urban ridership, and a 5.6% reduction in vehicle-hours even though vehicle miles increased by 8.5%. While total operating costs increased because of increased service, their operating cost per vehicle mile dropped by 8.5% and their operating cost per passenger trip dropped by 2.4%. In another application, Blacksburg Transit Authority (Virginia) implemented an automated scheduling system and AVL system on its fleet of 29 fixed-route and eight DRT vehicles in 1998. Blacksburg Transit has seen a 50% efficiency improvement in the scheduling of its passenger trips from 0.8 passengers per hour to nearly two passengers per hour. Overall system capacity was improved by providing service to a greater number of passengers with the same number of vehicles and drivers.

- Improved transit service and customer convenience – Operational software and computer aided dispatching systems provide improved transit service and convenience to customers in the form of improved transit service and response times in placing DRT trip requests, improved reliability in achieving estimates of predicted pickup/drop-off times, reduced trip travel times, and increase flexibility in the scheduling of desired services. For fixed route bus, operational software systems help maintain transit schedule adherence and coordinated transfers to minimize the wait time for transferring passengers. Bus operators are continuously informed of their schedule adherence, via on-board mobile data terminals. Transit dispatch coordinators are provided with information to adjust and restore scheduled transit services.
- Increased compliance with transit ADA requirements – The Americans with Disabilities Act (ADA) of 1990 requires fixed-route transit systems to provide complementary demand-responsive transit services for passengers, who live/work within a $\frac{3}{4}$ mile radius of a transit route, and who are unable to board a conventional transit vehicle. In addition, the ADA requirements stipulate that transit agencies are required to respond to previous day reservations and that passengers cannot be on board the vehicle longer than one hour. Demand responsive transit CAD systems facilitate the scheduling and handling of specialized transportation requests, and ensure compliance with ADA requirements.

Advanced Traveler Information Systems

There are many ways to characterize passenger information systems and generally they fall into the following categories:

- Itinerary planning systems – allow passengers to plan trips using one or more available transit services. These systems are directed to those transit passengers (tourists, visitors) who are making one-time trips or who are less familiar with available transportation services.
- Static information systems – preprinted information on system and route maps, schedules, fares, transfer points and other transit promotions. Also included is information through telephone, transit terminal displays, and transit internet web sites.
- Real time information systems – provide transit patrons with up-to-date information on scheduled transit vehicle arrival times, delays of routes, service disruptions, and re-routings. Generally this information is provided to transit riders through in-vehicle, bus stop or terminal display systems, automated telephone messaging systems, cable television, and through internet web sites.
- Transit accessibility systems – directed towards providing improved transit information to passengers with disabilities, and include “talking signs”, “talking kiosks”, telephone information systems, and in-vehicle enunciators.

There are many major deployments of advanced traveler information systems across the country many of which are integrated with other APTS technologies like AVL and the benefits are as follows:

- Increased transit ridership and revenues – Advanced traveler information systems have been found to be effective in promoting transit services to current and potential new transit patrons.
- Improved transit service and visibility within the community.
- Increased customer convenience – Applications of advanced traveler information systems provide a more convenient and potentially lower cost alternative for disseminating traveler information as compared to published transit schedules and telephone information systems.
- Enhance compliance to ADA requirements

The primary benefits in terms of dollars are in the form of increased transit ridership and transit revenues from passenger fares.

Other benefits referenced in the literature include:

- Rochester-Genesee Regional Transportation Authority has implemented and automated transit information system which answers 70% of information request calls. Information request calls have increased by 80%.

- San Diego County's interactive voice response system has allowed information agents to increase their productivity in handling calls by over 21%.

APPENDIX B

National Guidelines For The Evaluation Of APTS Systems

Technical Assistance Brief



U.S. Department
of Transportation

**Federal Transit
Administration**

Office of Technical
Assistance and Safety

APTS Evaluation Guidelines

The Advanced Public Transportation Systems (APTS) Program was established by the Federal Transit Administration (FTA) as part of the overall U.S. Department of Transportation Intelligent Vehicle Highway Systems (IVHS) initiative. (For a description of the APTS Program, see APTS Technical Assistance Brief 1, Spring 1993.)

Many innovative applications of APTS technology are being implemented at sites throughout the U.S. in the primary focus areas of Smart Traveler technologies, Smart Vehicle technologies, and Smart Intermodal Systems. Real world testing is being conducted in urban and rural areas using technologies such as automated vehicle location systems, smart card systems, dynamic ride sharing systems, passenger information systems, high occupancy vehicle systems, and vehicle component monitoring systems.

Most of the activity is being sponsored by the APTS Program as operational tests; however, there are also some local initiatives to innovate that will provide valuable information for the APTS Program. Both the local initiatives and APTS sponsored operational tests will be documented through evaluation plans developed

from comprehensive national guidelines to assure compatible data sets.

The various operational tests are meant to serve as learning tools and as models for other locales throughout the country. For these tests to have value and broad application, a consistent, carefully structured approach to project evaluation will be undertaken.

The purpose of the APTS project evaluations is to examine the effectiveness of APTS applications in real-world environments in terms of factors such as costs, benefits, and market response. Projects will be assessed on the success in meeting basic objectives such as enhancing the quality of transit service to customers, improving system productivity, and meeting community goals.

The Volpe National Transportation Systems Center has been charged with the task of developing a set of APTS Evaluation Guidelines that provide a common framework and methodology for evaluating individual operational tests.

While all sites will be evaluated using the common guidelines, the guidelines are not intended to be all inclusive that is, they do not offer a suggested or preferred course of action for every conceivable situation that might arise. Since each operational site is unique, each site will require a tailor made evaluation plan based on the model Evaluation Guidelines. □

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Evaluation Process

The evaluation process can be thought of as a link between the conduct of an operational test at a particular site and the understanding of its actual performance at that site. The quality of the evaluation process directly influences the accuracy of the operational test assessment and ultimately affects the applicability and transferability of test findings.

The evaluation process consists of four major phases: the evaluation frame of reference; evaluation planning; evaluation implementation; and potential evaluation spin-offs.

□ Evaluation Frame of Reference

The evaluation reference establishes the background and description of (1) the operational test; (2) the APTS Program objectives; (3) local objectives, issues, and site characteristics; and (4) potential external influences.

□ Evaluation Planning

The evaluation planning phase of the process transforms the evaluation frame of reference into a detailed, structured plan for conducting the evaluation. This plan contains the measures, data collection sources and requirements, and analysis/ derivation techniques needed to properly assess the costs, functional characteristics, efficiency, effectiveness, and other impacts of the equipment or service to be implemented.

□ Evaluation Implementation

The evaluation implementation phase is the period during which the evaluation plan is executed. This includes recording of project implementation and operational history, collection and analysis of data related to project objectives, and recording of external factors that might influence the operational test findings and results. This phase culminates with the preparation of the final summary project report which discusses the attainment of project objectives, insights into important project issues, assessment of the influence of site-specific or external factors on project results, and lessons learned relative to the implementation and operation of APTS applications.

□ Evaluation Spin-offs

Final evaluation reports will be widely disseminated so that other interested parties may share in the findings. While essentially documenting the history and effects of single projects, these evaluation reports also serve the broader function of increasing the understanding, and stimulating the application of APTS technologies in other localities.

Information presented in the reports will provide a basis for comparing the effects of a particular APTS application with those of similar projects and developing cross cutting studies. It is anticipated that the information from APTS evaluations will be valuable in the local planning process to help local decision makers determine which APTS technolo-

gies should be included on local Transportation Improvement Programs, State Implementation Plans, and Long Range Plans.

□ Evaluation Responsibilities

The evaluation process is a cooperative effort among FTA, the local transit operator, the equipment manufacturer/supplier, the Volpe Center, and the evaluation contractor. The FTA has the overall authority and responsibility for the project and has final approval for the project summary report.

The local agency is responsible for the installation, operation, and maintenance of the system and for working with the evaluation contractor. Local agency staff will provide much of the data for the evaluation, as well as their observations of day to-day operations.

The equipment manufacturer/supplier is expected to finish non proprietary equipment installation requirements; hardware and software descriptions and specifications; and actual costs of equipment and installation.

The Volpe Center staff will provide overall evaluation guidance, direct the evaluation contractor, monitor the contractor's performance, and review the documents prepared by the contractor.

The lead role in the evaluation process belongs to the evaluation contractor who will prepare the evaluation plan, conduct the evaluation, and present the findings in a final report. □

Impact Measures

Each detailed evaluation plan will contain a listing of relevant measures to be considered in order to perform a thorough evaluation of the APTS operational test. Through an examination of these measures, the evaluation will be able to determine the extent to which the APTS field test has attained the initial objectives.

The measures have been organized into performance categories. These categories are: financial impacts, functional characteristics, user acceptance, transit system efficiency and effectiveness, and other impacts.

- Financial impact measures relate to the costs of implementation and operation of the APTS service or equipment. These include the fixed costs of hardware, software, and other equipment, as well as such variable costs as marketing, administration, operations, maintenance, and supplies.
- Functional characteristics measures are designed to assess equipment performance. Questions surrounding the accuracy, reliability, maintainability, adherence to specifications, and other equipment aspects will be examined.
- User acceptance measures are one means of assessing the objective of servicing the customer. Both objective measurements of APTS usage and

public perceptions of APTS applications are indicators of user acceptance.

- Transit system performance is typically viewed in terms of efficiency and effectiveness, both of which may be influenced by the APTS application and other technology. Efficiency is gauged by the manner in which vehicles, personnel, fuel, and financial resources are employed to produce transportation service. Specific measures include the cost of service delivery, worker productivity, and vehicle utilization. Measures of transit system effectiveness include cost and revenue effectiveness and non-financial aspects such as service utilization, service reliability and quality, revenue generation, safety, and security.
- In addition, other impacts associated with the use of an APTS application may occur. Such impacts may relate to the transit agency's personnel, organizational concerns, and administrative procedures; assistance in achieving community goals; assistance in responding to national mandates such as the Americans with Disabilities Act, the Clean Air Act, and other Federal legislation; traffic congestion mitigation; institutional relationships; new technology advancement; human factors. Both quantitative and qualitative measures are required to assess these issues. □

Evaluation Planning Considerations

Once the relevant measures for project evaluation are determined, it is necessary to identify appropriate collection or derivation techniques, the frequency of collection, and the time period over which the data will be assembled.

A significant aspect of the evaluation process is determining the basic data collection and analysis design to be employed. In general, a single set of measurements (for example, measurements collected while the test is in operation) will be insufficient for assessing the impact of the test, since it will not provide a yardstick with which to interpret the data.

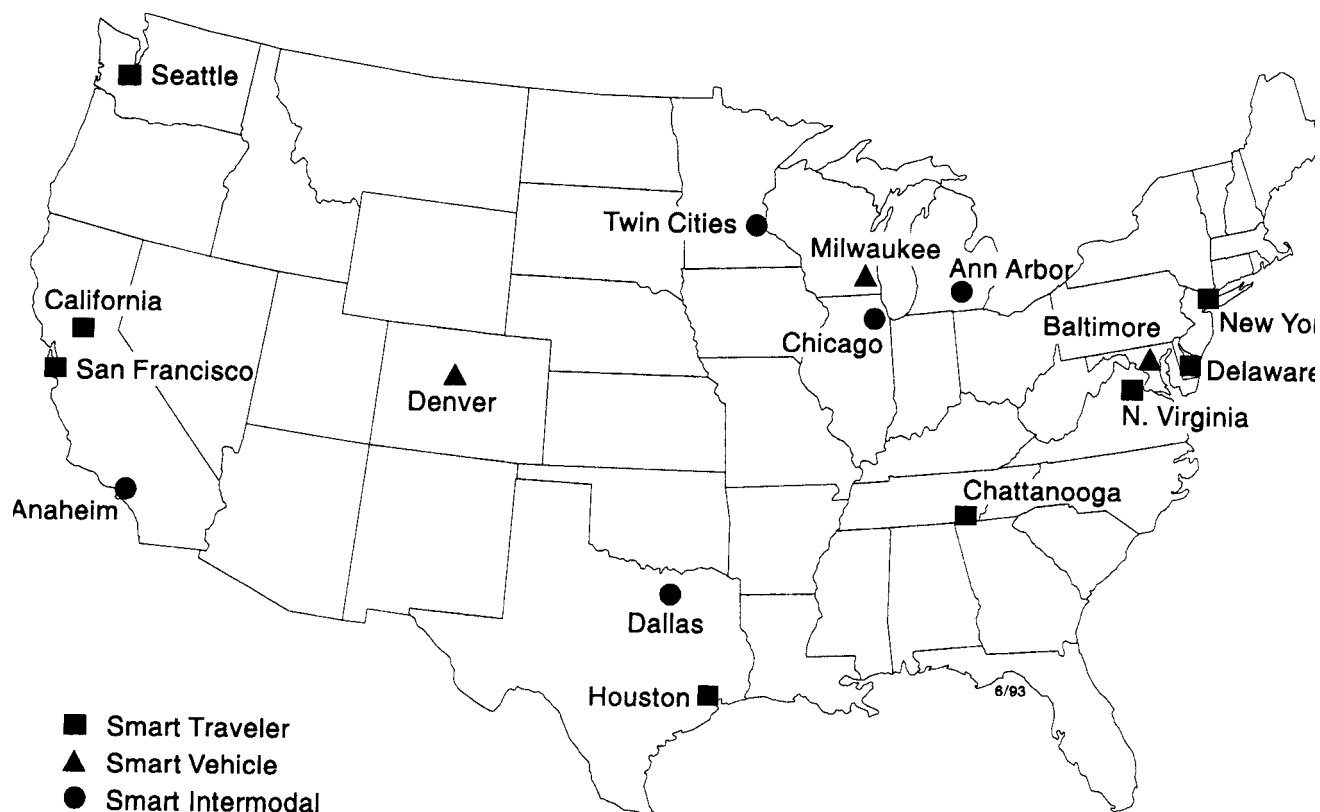
Given that the basic data collection/analysis design will generally be in the form of a comparison of multiple measurements, the type of comparison must be carefully selected.

The two main forms of comparison are *before* vs. *after* and *test* vs. *control*. Each type of comparison has limitations: the before-after comparison fails to show what portion of the change in the measure is due to external factors; the test-control comparison shows the difference between "after" measures but fails to indicate the degree of change from the before state to the after state. Therefore, it is desirable, where feasible, to conduct a before-after comparison in conjunction with a test-control comparison. □

Evaluation locations

There are a variety of local initiatives and APTS operational tests being evaluated across the U.S. The evaluations cover all three focus areas of the APTS Program: Smart Traveler technology, Smart Vehicle technology, Smart Intermodal Systems. For more information: phone (202) 366-4995, fax (202) 366-3765.

APTS OPERATIONAL TESTS



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