Evaluation of the Cape Cod Advanced Public Transit System

Phase 1 and 2

final report

prepared for

Volpe National Transportation Systems Center

prepared by

Cambridge Systematics, Inc.

January 2003

final report

Evaluation of the Cape Cod Advanced Public Transit System

Phase 1 and 2

prepared for

Volpe National Transportation Systems Center

prepared by

Cambridge Systematics, Inc.
150 CambridgePark Drive, Suite 4000
Cambridge, Massachusetts 02140

January 2003

Table of Contents

Table of Contents
(continued)

List of Tables

List of Tables
(continued)

List of Figures

List of Figures
(continued)

Acknowledgments

This report evaluates the Cape Cod Advanced Public Transit System (APTS) project, an application of Intelligent Transportation Systems to fixed-route and paratransit operations in a rural transit setting. At the state and federal levels, the Cape Cod APTS project is supported financially by the Massachusetts Executive Office of Transportation and Construction, the Federal Highway Administration's (FHWA) Joint Program Office for Intelligent Transportation Systems, the FHWA's Office of Research, Demonstration, and Innovation, and the Federal Transit Administration. The Cape Cod APTS project was initiated through a partnership between the Cape Cod Regional Transit Authority and the Moakley Center for Technological Applications at Bridgewater State College. The project is supported locally by the Cape Cod Commission and the Cape Cod Economic Development Council.

This evaluation was funded by the FHWA Joint Program Office for Intelligent Transportation Systems. Robert Casey of the Volpe National Transportation Systems Center oversaw the evaluation. The evaluation was conducted by Christopher Porter, Lynn Ahlgren, and Louisa Yue of Cambridge Systematics. The authors acknowledge the assistance of Larry Harman at Bridgewater State College and the staff of the Cape Cod Regional Transit Authority, especially Dennis Walsh, Paul Smith, and Aparna Sachidanand, in providing information to support this evaluation.

1.0 Introduction

The Cape Cod Regional Transit Authority's (CCRTA) Advanced Public Transportation System (APTS) project is an application of Intelligent Transportation Systems (ITS) to fixed-route and paratransit operations in a rural transit setting. The purpose of the project is to apply ITS technology to improve intermodal transportation services for the residents of rural Cape Cod as well as for visitors to the region. The specific problems and issues that the sponsors of the Cape Cod APTS project intended to address are:

- Access to jobs for year-round residents and the summer workforce;
- Integration of public transit into an intermodal system through improved service and effective and timely system information and payment mechanisms; and
- Severe traffic congestion in the summer tourist season on the region's highway system.

The Cape Cod APTS project was initiated through a partnership between CCRTA and the Moakley Center for Technological Applications at Bridgewater State College. The project is supported locally by the Cape Cod Commission and the Cape Cod Economic Development Council. At the state and federal levels, the project is supported financially by the Massachusetts Executive Office of Transportation and Construction, the Federal Highway Administration's (FHWA) Joint Program Office for Intelligent Transportation Systems (JPO/ITS), the FHWA's Office of Research, Demonstration, and Innovation, and the Federal Transit Administration (FTA). The project is an example of the use of the flexible funding provisions of the federal transportation statutes, and it is the first application of federal ITS funds to rural transit in a tourist economy.

This report primarily evaluates Phases 1 and 2 of the Cape Cod APTS project, which were implemented between October 1997 and June 2000. Phases 1 and 2 included the following components:

- An automatic vehicle location system (AVL) using global positioning systems (GPS) technology;
- Mobile data computers (MDC) on transit vehicles;
- A dedicated radio system for data transmission between MDCs and dispatchers;
- A "silent alarm" feature;
- A state-of-the-art fast local area network (LAN) at the CCRTA operations center;

- AVL/MDC host software that includes a geographic information system (GIS) mapping system to display real-time vehicle locations at the operations center; and
- An Internet site with GIS mapping so that customers can view real-time bus locations.

The Cape Cod APTS project has since continued into a third phase focusing on the demonstration of electronic fare payment systems and further development of customer information media, including an Internet-based travel planner. Electronic fare payment systems were implemented on a pilot basis beginning in summer 2001. For this pilot project, magnetic stripe cards were distributed free to guests and workers at participating hotels on the Cape. A customer survey was conducted in summer 2002 to evaluate the vehicle-travel and emissions benefits of the project. Except for this survey, Phase 3 activities are discussed but not evaluated in this report.

The remainder of this report is divided into six sections plus appendices:

- Section 2.0 provides context for the implementation of APTS on the Cape, including a description of the Cape's geography, population, and tourism base as well as an overview of CCRTA's services and funding sources;
- Section 3.0 describes the APTS system, including its components, the history of its implementation, and local goals and objectives for the system;
- Section 4.0 reviews goals and objectives for the National ITS program and identifies evaluation measures that relate to these objectives. These measures provide a framework for describing the benefits of the Cape Cod APTS project;
- Section 5.0 reviews, in detail, the various ways in which the APTS has affected CCRTA's operations as well as the benefits and other impacts to CCRTA and its customers;
- Section 6.0 summarizes findings regarding the benefits and impacts of the APTS as experienced to date;
- Section 7.0 draws conclusions and lessons learned with respect to implementation of APTS in a rural transit context;
- Appendix A is a list of acronyms;
- Appendix B describes the methodology and findings of a survey of transit tourist pass users undertaken during summer 2002; and
- Appendix C presents the survey instrument used for the tourist pass user survey.

2.0 Context

This section provides an overview of the context for introducing advanced technology to transit service on the Cape, including:

- The regional characteristics of the Cape, including its geography, population, and tourism patterns;
- The characteristics of transit service provided by CCRTA; and
- Sources of CCRTA's capital and operating funds.

2.1 Regional Characteristics

Geography

Cape Cod is a 413-square-mile, hook-shaped peninsula separated from the rest of Massachusetts by the Cape Cod Canal. This ecologically diverse land mass has natural areas of fields, forests, dunes, marshland, and beaches, including the 35-mile Cape Cod National Seashore on the northeast shoreline. The Cape's northern and western shoreline stretches along Cape Cod Bay, while Nantucket Sound borders its southern coast. Thirty-five miles in east-west length, the Cape has a bend at the end that extends another 30 miles to the north. This bend is known as the "lower Cape," while the area closest to the rest of Massachusetts is known as the "upper Cape"; from Hyannis to Chatham comprises the "mid-Cape" region.

The entire Cape is part of a single county, Barnstable. Within the Cape, there are 15 towns, each of which have a unique character and specialized transportation needs. Each of these towns typically includes one or more villages which represent areas of clustered settlement. Barnstable is the largest town on Cape Cod and consists of eight distinct villages, including Hyannis, the commercial center of the Cape. Towns and selected villages on the Cape are shown in Figure 2.1.

Linking the towns on the Cape are three major east/west roads: Route 28, Route 6A, and Route 6. Route 28 is lined by homes as well as scattered strip commercial development, including souvenir shops, fast food restaurants, mini-golf courses, and motels. Route 6A is a mix of moderately dense housing and small-scale commercial operations such as antique and gift shops. Both of these roadways reflect the Cape's heavy dependence on

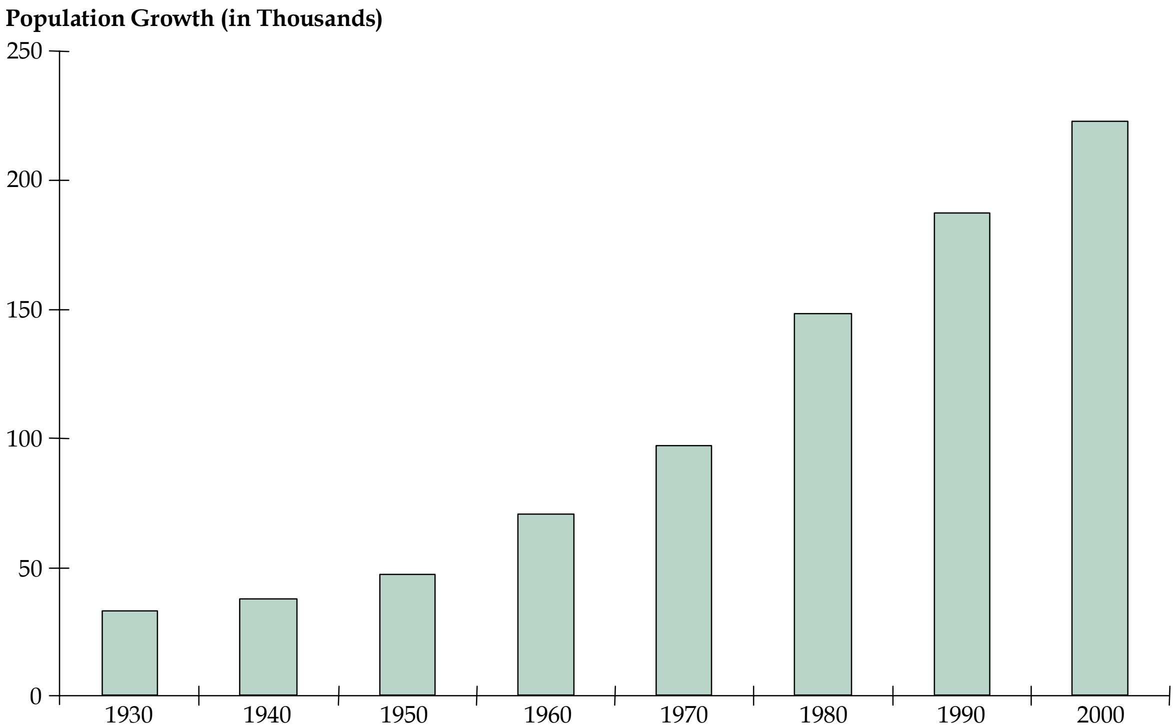
Figure 2.1 Cape Cod Towns and Highways

tourism as a year-round economic base. Route 6 provides a higher speed, limited access roadway stretching from the Sagamore Bridge to Orleans, beyond which it serves both through and local access functions to Provincetown at the tip of the Cape. To reach the Cape by ground, residents and visitors must cross either the Bourne or Sagamore Bridges. Both of these gateways are considered major pinch points in the overall flow of traffic, and experience considerable congestion during periods of heavy use such as summer weekends.

Population Characteristics

The year-round population of the Cape, as of the 2000 Census, is over 222,000. Population has been growing rapidly since 1950 (Figure 2.2). Two primary causes of this population growth are the area's desirability as a retirement destination and the increase in number of second homes that have been purchased on the Cape. Growth pressures have led to a rapid escalation in housing prices as well as increasing traffic congestion. Between 1995 and 2000, the Cape Cod Times reported an increase in the average price of a single-family home of 62 percent.[1]

Figure 2.2 Cape Cod Population Growth
1930-2000



Source: Cape Cod Commission, Barnstable, Massachusetts.

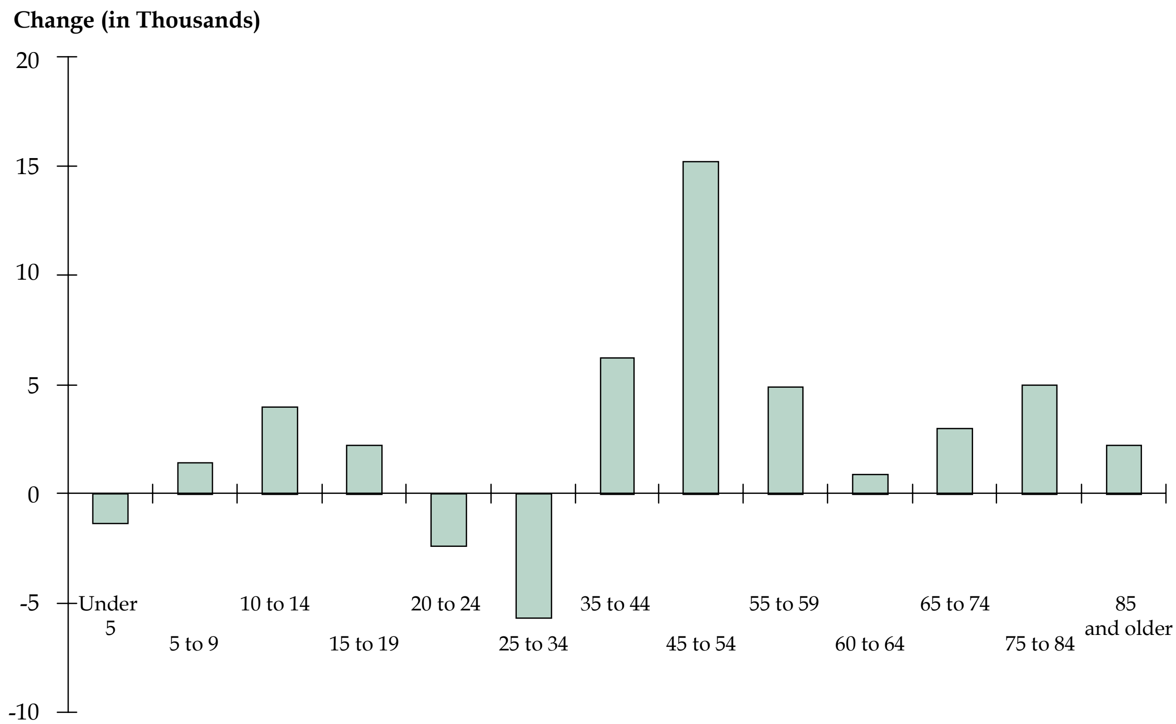
These economic and demographic factors also are leading to changes in the composition of the population by life-cycle and age group. Figure 2.3 illustrates recent population changes by demographic group. Critical in this figure are the increases in older populations which have a higher transit dependency rate than those of younger populations.

---

[1] Cape Cod Times Online. *Crisis at our Doorstep*, November 12-16, 2000.

Between 1990 and 2000, the overall population of the Cape increased by 19.1 percent. During this same period, the young adult population (those between the ages of 20 to 34), declined by 21.5 percent while the population of persons over 65 years of age increased by 24.6 percent. Currently, over 25 percent of all households on the Cape include individuals 65 years or older.

Figure 2.3 Change in Number of Cape Cod Residents by Age Group
1990-2000



In 1990, the Bureau of the Census declared an urbanized area in the mid-Cape area consisting of the Town of Barnstable (including the village of Hyannis) and contiguous densely settled areas of the Town of Yarmouth. With an overall density of 562 people per square mile, however, most of Cape Cod is classified as a rural area.[2] While the most prevalent mode used for transporting people in rural areas is the automobile, nationwide, one of every 14 households in rural America has no car, and 38 percent of United States residents who are classified as transit dependent live in rural areas.[3]

---

[2] Cape Cod Commission, Barnstable, Massachusetts.

[3] Zarean, M.; B. Buergler; J. Sajovec; J. Burkhardt; and C. L. Schweiger. *Rural Transportation Technologies: User Needs and Applications Final Report*. Prepared by TransCore/SAIC for U.S. Department of Transportation, January 1998.

Tourism and Transportation to the Cape

The Cape's tourism market provides an additional base of potential transit ridership. Tourism is the single largest industry on the Cape. The Massachusetts Office of Travel and Tourism estimates that in SFY (State Fiscal Year) 2000,[4] 4,700,000 visitors, representing 19 percent of all SFY 2000 domestic travel to Massachusetts, traveled to the Cape and the Islands (Martha's Vineyard and Nantucket). During SFY 2000, direct domestic traveler spending totaled $713 million in Barnstable County, generating $202 million in payroll as well as 9,400 jobs within the County.

Table 2.1 shows modes of travel used by visitors to the Cape. Most – just over three-quarters – come by private automobile. However, other modes, including airplane, bus, and ferry also carry significant numbers of people. The number of tourists arriving by modes of public transportation, as well as the shortage of parking in some Cape towns and at tourist attractions during peak visitation times, provides a base of potential tourist ridership for the Cape Cod transit system. Because of the influx of tourists, the population of the Cape has been estimated to triple to over 600,000 during the summer months.[5]

Table 2.1 Primary Modes of Transportation to Cape Cod

Own Car/Truck	76.2%
Airplane	13.4%
Bus	2.8%
Ship/Boat	2.7%
Camper/RV	1.7%
Rental Car	1.3%
Train	0.4%
Other	1.6%

Source: 1999-2000 Travel Scope. Travel Industry Association.

There are two public airports that are open to civilian aircraft on the Cape. Barnstable Municipal Airport in Hyannis is the larger of the two; a second airport at Provincetown handles a much lower volume of air traffic. Direct passenger ferry service is provided seasonally from Boston to Provincetown. Interregional bus service is provided by the Plymouth and Brockton Street Railway to Boston and Logan Airport from Falmouth, Hyannis, and Provincetown; and by Bonanza Bus Lines to Providence and New York City from Falmouth and Hyannis.

---

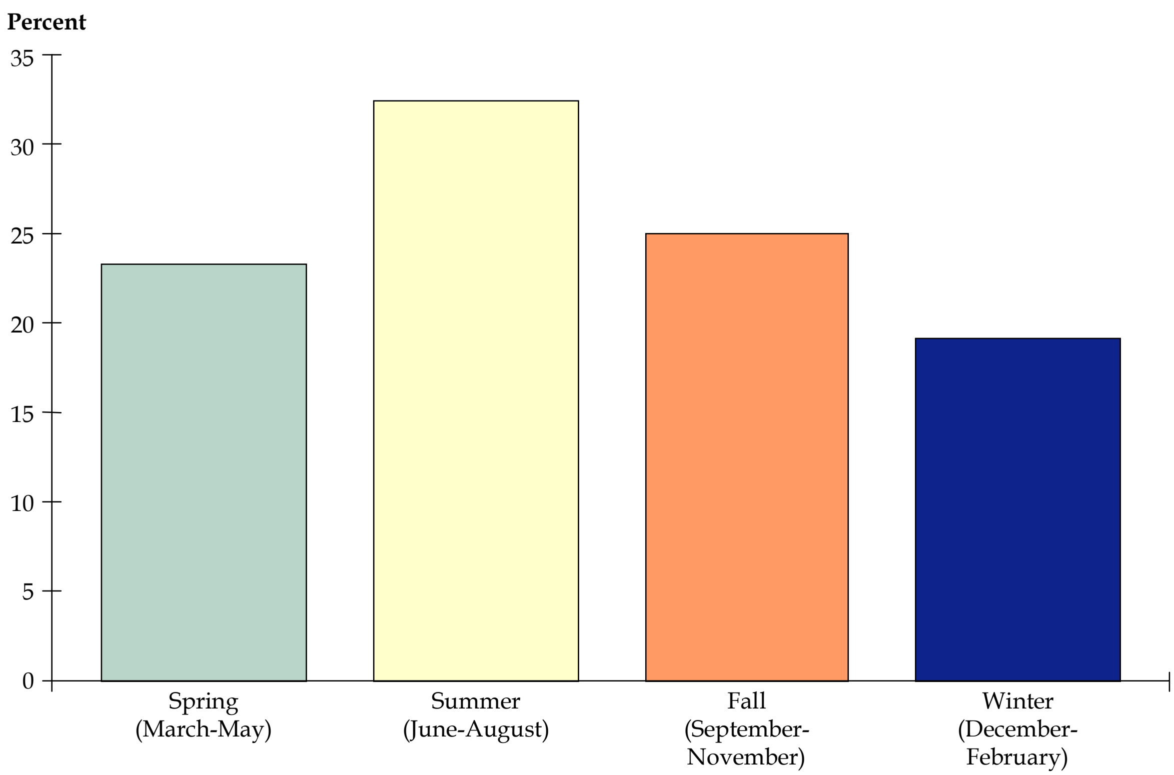
[4] The State Fiscal Year begins in July of the previous calendar year.

[5] Cape Cod Regional Transportation Authority, Moakley Center for Technological Applications, and the Viggen Corporation. *Cape Cod Transit ITS Proposal*. April 1997.

At the present time, there is no direct train connection from the Cape to the mainland. Bus connections exist from Boston and Providence Amtrak stations. Once on the Cape, however, the Cape Cod Central Railroad provides seasonal dinner and scenic excursions along Cape Cod Bay from Hyannis to the Cape Cod Canal.

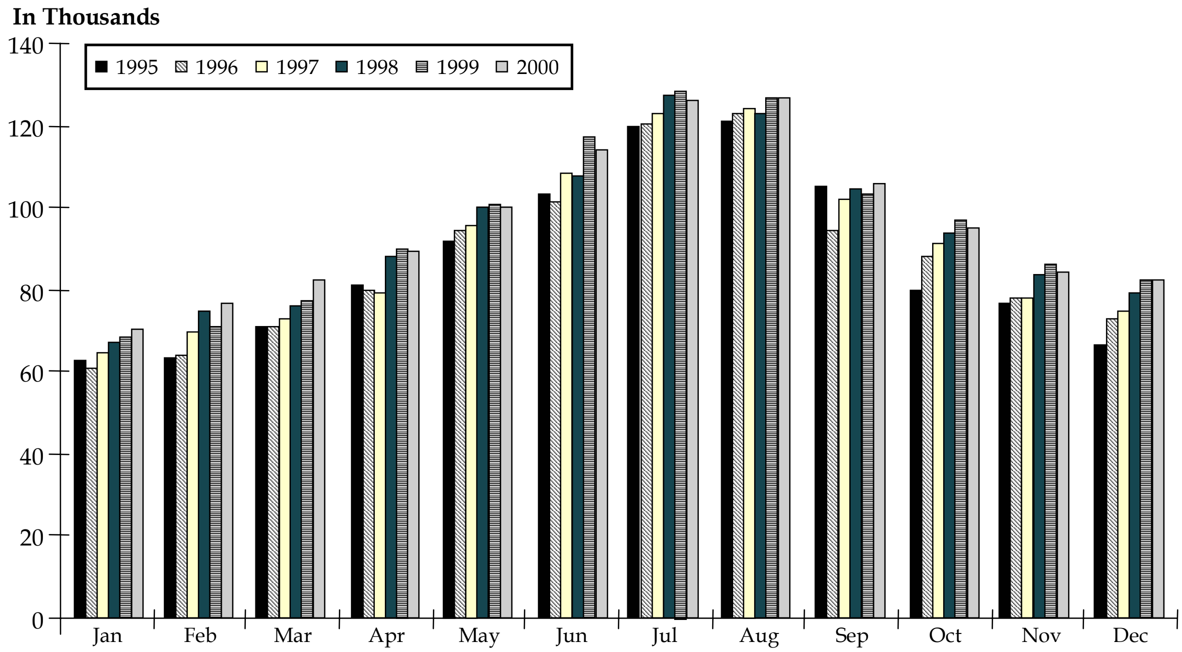
Regardless of how they get to the Cape, the number of tourists traveling to the Cape is subject to seasonality with summer travelers generating about 33 percent of the annual travel volume, fall and spring accounting for about 25 percent each, and winter generating 19 percent (Figure 2.4). Traffic counts taken at the Bourne and Sagamore Bridge confirm this seasonality with bridge traffic increasing during summer months. Figure 2.5 shows Cape Cod bridge travel by month from 1995 through 2000.

Figure 2.4 Tourism Seasonality



Source: Massachusetts Office of Travel and Tourism FY2000.

Figure 2.5 Cape Cod Bridge Traffic
1995-2000



Source: Army Corps of Engineers Traffic Counts for Bourne and Sagamore Bridges.

2.2 Transit Service on the Cape

CCRTA provides paratransit and fixed-route service to meet the transportation needs of the transit-dependent year-round population on the Cape. It also provides summer shuttle service in and between major villages, primarily to serve the tourist market and reduce traffic congestion. In addition, CCRTA provides a brokered transportation service for clients of several state human service agencies.

Institutional Structure and Staffing

CCRTA, like other regional transportation authorities in Massachusetts, was established by an act of the legislature. Operating funds are provided by the Massachusetts Executive Office of Transportation and Construction (EOTC). The agency is governed by a 15-person Board of Directors comprised of a representative from each town on the Cape. The agency contracts with Cape Area Transit Systems, Inc. (CATS), a subsidiary of First Transit (formerly ATE/Ryder Corporation), for the provision of transportation services.

CCRTA includes five permanent staff positions: administrator, assistant administrator, human services transportation coordinator, staff accountant, and executive assistant. CATS staffs the agency's operations center with an operations manager and assistant manager, five to six dispatchers, maintenance and mechanics personnel, and roughly 90 year-round drivers or vehicle operators. In addition, the Authority recently created an information technology/data analyst position to support the APTS hardware, software, and data.

Of the 90 operators that operate CCRTA service, about half are employed full time on CCRTA work. The remaining operators are either part-time or substitute workers. During the summer months an additional 40 to 50 operators are hired as temporary help.

Facilities and Fleet Details

Until November 2002, CCRTA administrative offices were located on Main Street in the village of Dennis, Massachusetts. As of November 2002, administrative offices were relocated to a new Intermodal Transportation Center in Hyannis. The CATS operations center is located near Route 6 in South Dennis. Operations management and dispatchers are located at the operations center, and buses maintained at this location. While some buses are stored at the operations center, while in use they are often taken home overnight by operators.

As of 2000, CCRTA operated a fleet of 29 fixed-route buses and 69 demand responsive vehicles. The average age of a CCRTA fixed-route bus was 11.2 years. The paratransit fleet is much younger with an average vehicle age of only 4.5 years.[6] As reported in the National Transit Database, the Authority has no spare fixed-route vehicles and 15 percent spare vehicles for paratransit service. The Authority leases trolley vehicles for its summer trolley services. All of the vehicles used to provide CCRTA service are wheelchair accessible pursuant to the 1990 Americans with Disabilities Act (ADA) and all fixed-route vehicles are equipped with bicycle racks to encourage intermodal usage.

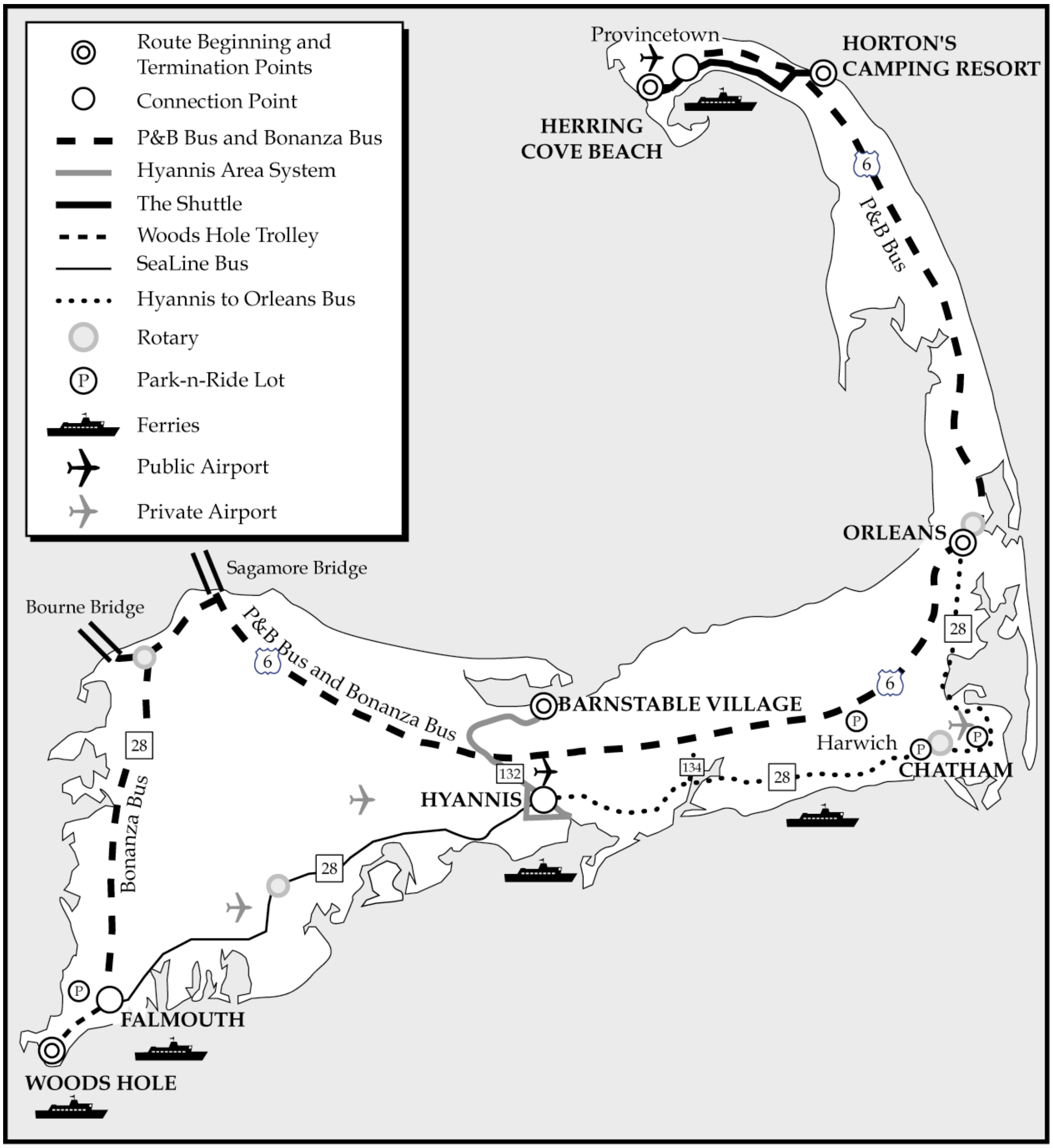
Fixed-Route Service

Routes

CCRTA currently operates four year-round fixed routes on the Cape, two providing east-west service across the upper and mid Cape and two providing local service in the mid-Cape region (Hyannis). In addition, CCRTA operates summer shuttles in local areas of high tourist activity. To board a bus, passengers can either wait at any designated bus stop or simply wave to the driver to stop anywhere along the route. Routes as of early fall 2001 are shown in Figure 2.6.

[6] National Transit Database, 2000.

Figure 2.6 Transit Service on Cape Cod



In general, service is provided on weekdays from early morning through early evening, with more limited hours on weekends. The year-round fixed routes normally provide service Monday through Saturday, although Sunday service was introduced on an experimental basis during the summer of 2001 and continued in summer 2002. On the two longer-distance SeaLine and Hyannis to Orleans routes, service operates with relatively low and irregular frequencies due to limited budgets and a large service area.

The summer trolleys have provided seven-day service, typically on frequencies of 20, 30, or 60 minutes, since their inception. Some provide late-evening service on weekends. Peak-season summer service is provided from late June through Labor Day weekend; transitional service, expanded for summer 2001 and 2002, is provided on some shuttle routes from mid-May through late June and from Labor Day through mid-October.

The year-round routes operated by CCRTA include:

- **Hyannis Area Service (Villager and Bearse's Way Shuttle) –** The Villager is a regularly scheduled route with service from Hyannis to Barnstable Village. Expanded service to Barnstable Harbor is available through mid-October. The Villager provides connections with intercity buses, the SeaLine to Falmouth, and the H2O Line to Orleans. There are 10 to 15 runs per day on the Villager's year-round service. Hyannis area service, including the Villager and summer shuttles, was significantly revised for the summer of 2001. The Bearse's Way Shuttle now provides year-round local service in Hyannis, complementing the Villager route.

- **The SeaLine Bus –** The SeaLine provides service between Falmouth village, Mashpee, Barnstable, and Hyannis, with extended service to Woods Hole during selected periods of the year to coordinate with the availability of the Woods Hole Trolley. At its terminus in Hyannis, the SeaLine connects with the Hyannis to Orleans route (H2O Line); Hyannis area service to Main Street, shopping malls, Cape Cod Community College and Barnstable Village; and intercity bus service to Provincetown, Boston, Providence, and New York City. All of the connections are made at the Plymouth & Brockton (P&B) bus station at the east end of downtown Hyannis (as of November 2002, all connections are now made at the Intermodal Transportation Center in Hyannis). The SeaLine has typically had eight weekday and four weekend runs, although service was increased during summer 2001 and 2002 to eleven weekday and seven weekend runs.

- **The Hyannis to Orleans (H20) Bus –** The H2O Line provides service along Route 28 from Hyannis to Yarmouth, Dennis, Harwich, Chatham, and Orleans. The H2O connects with Hyannis area service, the SeaLine bus to Falmouth, and intercity bus service at the Hyannis terminal. The H2O Line has typically had six weekday and four weekend runs, although service was increased during summer 2001 and 2002 to eight weekday and six weekend runs.

The summer shuttles provided by CCRTA (as of summer 2001) include:

- **The Woods Hole Trolley (WHOOSH) –** The Woods Hole Trolley runs between Falmouth Mall and the Aquarium in Woods Hole, with service to the Steamship Authority's docks for ferry service to Martha's Vineyard. Transfers are available to East Falmouth, Mashpee, and Barnstable (including Hyannis) by switching to the SeaLine bus at Falmouth Mall. In addition, service is available to the Falmouth Bus Depot on request. During summer 2001, the Trolley operated seven days a week at 20- to 30-minute intervals from 9:30 a.m. to 7:10 p.m., with early morning and evening service provided on Fridays and Saturdays.

- **The Provincetown-Truro Shuttle ("The Shuttle") –** Initiated in summer 2000, the Shuttle provides service between Provincetown and North Truro. The shuttle serves the ferry from Boston to Provincetown, beaches, and other tourist destinations and lodging in the area. While the route primarily serves tourism destinations, it also stops on request at the Outer Cape Health Service and Maushop Senior Housing, and serves workers as well as tourists. During summer 2001, the Shuttle operated seven days a week at 20- to 60-minute intervals, including late evening service on Fridays and Saturdays. The Shuttle has provided the single highest ridership on CCRTA system, with over 70,000 estimated riders in summer 2001 – 46 percent of all fixed-route transit ridership on the Cape for the entire year.

- **The North Falmouth Shuttle –** This service runs south from the intersection of Routes 28A and 151 to Falmouth Mall, where it connects with the SeaLine and Woods Hole Trolley. The service, initiated in summer 2001, runs hourly from 7:00 a.m. to 5:00 p.m. daily. Another service, the Falmouth-Mashpee Trolley, which also terminated at the Falmouth Mall but ran east to Mashpee, was discontinued for 2001.

- **The Yarmouth Trolley –** This trolley operates from the P&B bus station in Hyannis east along Route 28 to Yarmouth, with detours to serve beach destinations. It operates at 30- to 60-minute headways from 9:00 a.m. to 10:00 p.m. Prior to summer 2001, the Yarmouth Trolley connected with the Dennis Trolley, which served shopping and tourist destinations in Dennis (east of Yarmouth). However, the Dennis Trolley was discontinued in 2001 due to low ridership.

- **Hyannis Area –** Prior to 2001, the Hyannis Area Trolley (HAT) provided service in the Hyannis area on two lines known as the Main Street Route and the Mall Route, which connected at the P&B bus terminal. As of summer 2001, service in the Hyannis area was revised. It now consists of the Villager Trolley, which runs every 20 minutes along the route of the off-season Villager Bus; the Bearse's Way Shuttle, which runs every 30 minutes locally in Hyannis; and the Hyannis Beaches Trolley, which runs every 30 minutes from the Hyannis terminal to oceanfront destinations. Also, during summer 1999, the Hyannis Park-and-Ride Shuttle was introduced to connect a park-and-ride lot near Route 6 with the ferry terminal in Hyannis. However, this service was redundant with the service restructuring introduced in 2001 and has been discontinued.

Fares and Fare Payment Systems

As of 2001, CCRTA regular adult bus fares start at $1.00 per ride and increase to $3.50, depending on the length of the ride. Half-price discounts are provided for senior citizens (60 years and older) and people with disability ID cards. In addition, children five or younger, accompanied by an adult, ride for free. On the summer trolley routes, regular adult fares are $1.00 with half-price fares for seniors, disabled, and youth; one-day passes are also available for three times the single-ride fare. The current fare structure has been in effect since SFY 1998.

Multi-ride discounts and one-day passes are provided for various services throughout the CCRTA service district. For example, on the SeaLine and H2O routes, frequent riders can purchase reduced fare tokens at a 25 percent discount. Discount tokens for use on the shuttle and the trolley are available at the Bay State Cruise Company offices, the

Provincetown Chamber of Commerce, and the Falmouth Chamber of Commerce. Discount passes are available for students and frequent users from the operator on the SeaLine and H2O routes. Discounted fares allow frequent riders to ride 20 times for the price of 15.

Demand Responsive Service

CCRTA provides Cape Cod residents of all ages and abilities with a door-to-door ride-by-appointment service for travel for any purpose, including school, work, and shopping or medical appointments. The service is known locally as "B-Bus." The provision of paratransit service to the general public is important in meeting rural transportation needs, as it may not be financially or operationally feasible to provide fixed-route transit coverage and frequencies in low-density areas at a level that is conducive to regular usage.

Service Hours/Availability

Paratransit service is provided seven days a week throughout the year with hours of operation varying based upon town location. In general, service is provided from 7:00 a.m. to 7:00 p.m. Monday through Friday. Saturday service is available from 9:00 a.m. to 7:00 p.m. and Sunday service is available from 9:00 a.m. to 1:00 p.m.

Procedures for Registering/Scheduling a Paratransit Trip

While paratransit service is open to all residents of the Cape, prior to using the system the potential user must register with CCRTA. To register, residents must contact the CCRTA operations center between 1:00 p.m. and 4:00 p.m. During this call, the dispatcher will complete the enrollment forms and explain the system's rules.

Once enrolled, reservations may be made up to a week in advance by calling CCRTA between 8:00 a.m. and 4:00 p.m. on weekdays. System users are encouraged to schedule their trips as far in advance of their trip as possible to improve their chances of getting the closest possible match to the actual requested trip times. The cut-off time for scheduling a trip is 11:00 a.m. the day prior, for rides during the week, and 11:00 a.m. on Friday for weekend and Monday service. On occasion, trips are scheduled after this time, but the practice is not encouraged as it may not be possible to accommodate the trip.

CCRTA encourages deaf riders to use the system and has installed a telecommunications device for the hearing impaired (TDD) service to handle trip requests. The service is available between 7:30 a.m. and 11:00 a.m.

Users of the paratransit services must allow a 30-minute window on either side of their scheduled pick-up times to accommodate variations in traffic and running times for the paratransit drivers.

Fares for using paratransit services are listed in Table 2.2. The Authority offers two methods of payment: cash or billed. If opting to be billed, riders can select either a flat fare rate or the agency's frequent rider program, which offers discounts to riders who use the system frequently.

Table 2.2 CCRTA Paratransit Fare Structure

B-Bus Fares	Adults and Children Six and Older	Seniors and People with Disabilities
General Trips Each Way	$2.00 plus 10 cents per mile	$1.00 plus 5 cents per mile
Medical Trips Each Way	$1.50	$0.75
Frequent Rider Program	$10.00 monthly fee allows half off the above B-Bus fares	$5.00 monthly fee allows half off the above B-Bus fares

Service Areas

CCRTA dispatchers schedule paratransit manifests by trip location and purpose. While there are no geographic limitations within the Cape as to the town in which the vehicles operate, trip schedulers have found that it is most efficient to operate vehicles within a "home base." This way the drivers get to know the area and the customers.

Trips with similar purposes are also generally grouped together. For example, seniors going to a program at the senior center are grouped together as they have a common destination or trips to the hospital are usually put on the same vehicle so that the vehicle can drop off multiple passengers at one time.

Ridership and Operating Statistics

In calendar year 2000, the most recent full year of operating data available from CCRTA, CCRTA provided 104,700 total vehicle-hours of service, of which roughly two-thirds were paratransit service. The remaining fixed-route service was split almost equally between the year-round bus routes and the summer shuttles. In 2000, CCRTA carried 184,000 passengers on the B-Bus paratransit service, 94,000 on the year-round buses, and 141,000 on the summer shuttles. The average cost per passenger this year was about $4.00 on the summer shuttles, $7.00 on the year-round bus routes, and $12 on the paratransit system.

Ridership and operating statistics for calendar years 1997 through 2001 are summarized in Tables 2.3 and 2.4. Figures 2.7 and 2.8 illustrate trends in ridership and service provision. Ridership has been increasing on the fixed-route services, consistent with an increase in the amount of service provided, but paratransit service provision and use has been declining slowly. This trend is consistent with CCRTA's long-term objective of shifting ridership to fixed-route services from paratransit in order to reduce service costs per passenger.

Table 2.3 CCRTA Operating Statistics
Fixed-Route Services

	Summer Shuttles					Year-Round Buses				
Calendar Year	**1997**	**1998**	**1999**	**2000**	**2001**	**1997**	**1998**	**1999**	**2000**	**2001**
Total Vehicle Trips	10,478	9,730	14,598	14,547	N/A	10,836	12,115	13,509	13,972	N/A
Total Vehicle Hours	7,734	7,821	10,124	16,267	15,201	13,532	16,749	17,977	19,630	28,940
Total Vehicle Miles	100,820	96,528	131,667	218,439	209,186	260,333	265,085	287,420	308,107	443,988
Total Passengers	77,216	76,993	89,625	141,021	148,369	81,194	80,310	89,377	93,679	144,232
Pass./Vehicle-Hour	9.98	9.84	8.85	8.67	9.76	6.00	4.79	4.97	4.77	4.98
Pass./Vehicle-Mile	0.77	0.80	0.68	0.65	0.71	0.31	0.30	0.31	0.30	0.32
Total Revenue	$42,655	$48,403	$51,073	$101,401	$89,329	$74,459	$89,340	$97,081	$106,855	N/A
Total Cost	$253,880	$240,484	$351,709	$567,331	$534,260	$471,993	$512,660	$550,511	$655,656	N/A
Net Cost	($211,225)	($192,080)	($300,636)	($465,931)	($444,931)	($397,534)	($423,320)	($453,431)	($548,802)	N/A
Cost/Passenger	$3.29	$3.12	$3.92	$4.02	$3.60	$5.81	$6.38	$6.16	$7.00	N/A
Cost/Hour	$32.83	$30.75	$34.74	$34.88	$35.15	$34.88	$30.61	$30.62	$33.40	N/A
Cost/Mile	$2.52	$2.49	$2.67	$2.60	$2.55	$1.81	$1.93	$1.92	$2.13	N/A
Average Fare	$0.55	$0.63	$0.57	$0.72	$0.60	$0.92	$1.11	$1.09	$1.14	N/A

Table 2.4 CCRTA Operating Statistics
Paratransit Services

	Paratransit (B-Bus)				
Calendar Year	**1997[1]**	**1998**	**1999**	**2000**	**2001**
Total Vehicle Hours	55,078	61,706	69,795	68,815	63,598
Total Vehicle Miles	1,400,342	1,282,963	1,154,528	1,162,079	1,064,998
Total Passengers	219,758	206,575	194,513	183,513	169,803
Pass./Vehicle-Hour	3.99	3.35	2.79	2.67	2.67
Pass./Vehicle-Mile	0.16	0.16	0.17	0.16	0.16
Total Revenue	$265,922	$286,767	$293,029	$288,817	N/A
Total Cost	$1,548,369	$1,692,463	$1,940,657	$2,222,891	N/A
Net Cost	($1,282,447)	($1,405,696)	($1,647,628)	($1,934,074)	N/A
Cost/Passenger	$7.05	$8.19	$9.98	$12.11	N/A
Cost/Hour	$28.11	$27.43	$27.81	$32.30	N/A
Cost/Mile	$1.11	$1.32	$1.68	$1.91	N/A
Average Fare	$1.21	$1.39	$1.51	$1.57	N/A

[1] Extrapolated from July-December data.

Figure 2.7 CCRTA Ridership Trends

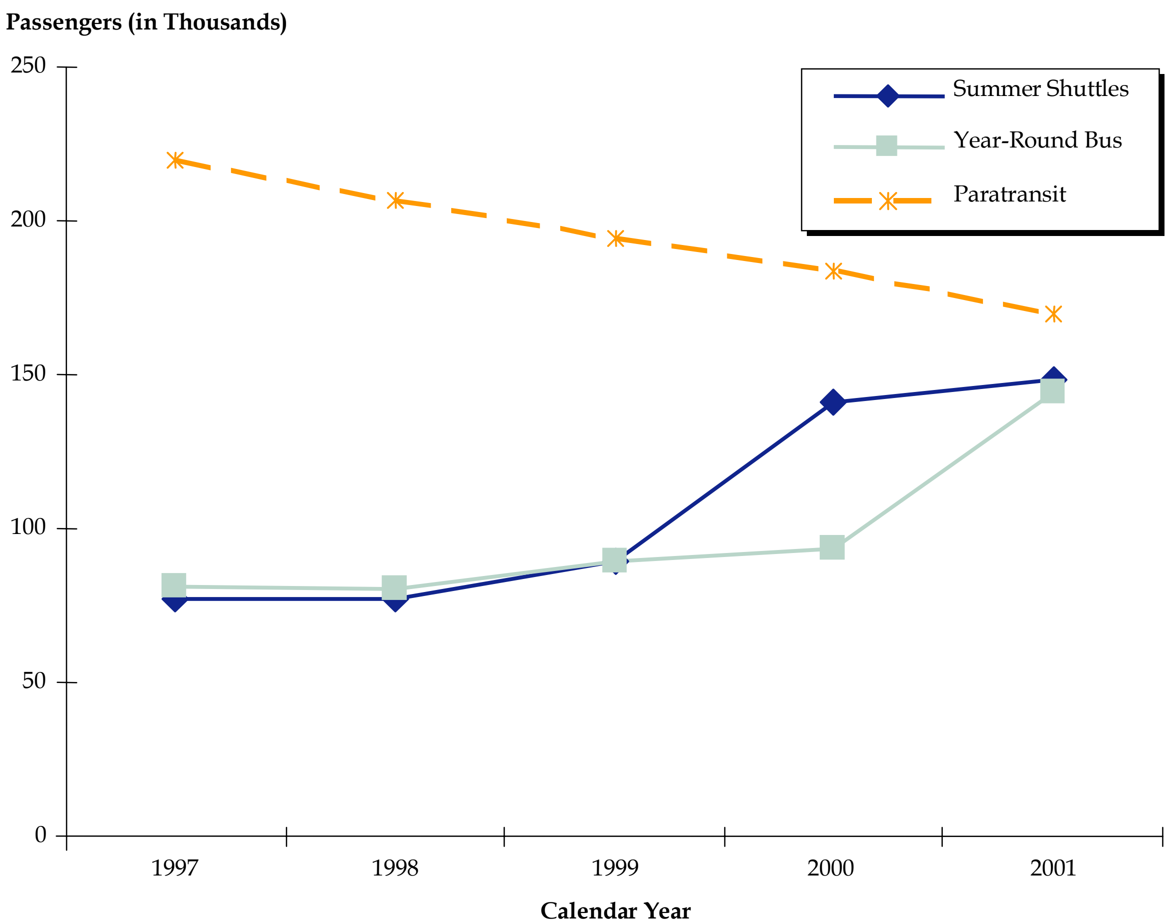
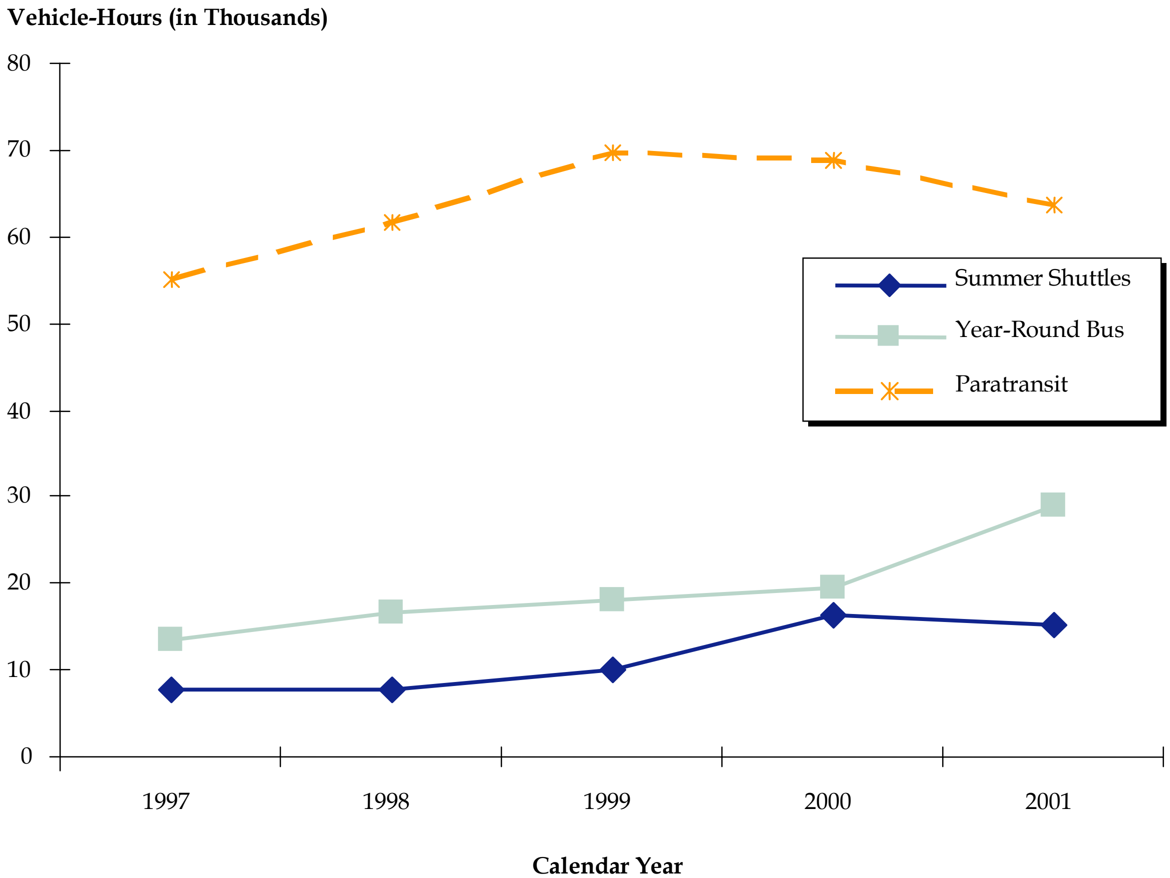


Figure 2.8 CCRTA Service Provision Trends



All paratransit trips are tracked according to client and trip purpose. As Table 2.5 shows, Cape residents use the B-Bus for a variety of trip purposes, with some of the most common being employment, medical, shopping, nutrition, and social/recreational. Table 2.6 describes the type of user of the B-Bus. Over three-quarters are elderly; approximately five percent (including elderly and non-elderly) are non-ambulatory or wheelchair-dependent. These sample statistics are shown for SFY 2000, which runs from July 1999 through June 2000.

Table 2.5 Paratransit Trips by Purpose

Trip Purpose	Total	Percent
Medical	22,240	11.4%
Employment	40,789	20.9%
Nutrition	16,586	8.5%
Social/Recreational	13,491	6.9%
Education	4,379	2.2%
Shopping	19,157	9.8%
Other	78,465	40.2%
Total	**195,107**	**100.0%**

Table 2.6 Paratransit Trips by Client Type

Client Type	Total	Percent
Elderly Ambulatory	141,255	72.4%
Elderly Non-Ambulatory (Wheelchair)	9,266	4.7%
Non-Elderly Ambulatory Riders	43,600	22.3%
Non-Elderly Non Ambulatory (Wheelchair)	986	0.5%
Total	**195,107**	**100.0%**

Other Transit Service Details

Human Services Transportation

CCRTA provides a brokered transportation service for clients of several state agencies, including the Department of Mental Retardation (sheltered workshop transportation), the Division of Medical Assistance (Medicaid transportation), and the Department of Public Health (Early Intervention transportation). While these services were taken over during SFY 1998 through 2001 by the Greater Attleboro Taunton Regional Transit Authority (GATRA), CCRTA resumed providing these services for SFY 2002, with a transition period from July through December 2001, as a result of change in geographic coverage for service providers initiated by the state Human Services Transportation (HST) initiative. CCRTA provides this service using the fixed-route, B-Bus, or taxis, in that order of preference. In response to study recommendations to coordinate human service transportation on the Cape, CCRTA also provides service to the elderly for the Council on Aging (COA). CCRTA tracks trips provided for specific human services agencies separately from trips taken for general purposes and bills trips to the respective agencies.

To meet the goal of welfare reform, the Commonwealth of Massachusetts implemented a Welfare to Work Initiative in December of 1998 to address the transportation needs of current and former welfare recipients who are transitioning off of public assistance and into the workforce. Known as "Access to Jobs," the $5 million statewide program serves as the transportation component of welfare reform in Massachusetts. CCRTA is an active partner in the Commonwealth's Access to Jobs program and as such has provided transit passes to persons transitioning off public assistance.

Coordination with Other Transit Agencies or Services

CCRTA buses connect with coaches serving Boston, Providence, and other locations throughout New England. The main bus connection locations are at the Hyannis Terminal and at the Falmouth bus depot. Plymouth and Brockton buses provide service to downtown Boston and Logan Airport. The Bonanza Bus Lines serve Providence and New York City from Hyannis and Boston and Logan airport from the Falmouth location.

CCRTA's Villager route makes connections to ferry services at the Steamship Authority docks in Hyannis for travel to Nantucket, and at the Hy-Line Cruise docks in Hyannis for travel to Nantucket and Martha's Vineyard. It also serves the Barnstable Municipal Airport. The Woods Hole trolley operates seasonally to the Steamship docks in Woods Hole for travel to Martha's Vineyard, with the SeaLine providing extended service to Woods Hole during the off-season when the trolley is not running. In addition, the seasonal North Truro to Provincetown Shuttle provides connections to the MacMillan Wharf with ferry service to Boston and Plymouth.

2.3 CCRTA System Funding

Capital Funding Sources

CCRTA's capital needs are funded through a combination of federal, state, and local sources. For the period 1996 through 2000, CCRTA's capital expenditures totaled roughly $5 million, of which two-thirds was from federal sources and most of the remainder was from state sources (see Table 2.7). Of this $5 million, roughly two-thirds went to purchase rolling stock and one-third towards facilities and other equipment. It should be noted, however, that during this period CCRTA received federal grants totaling roughly $800,000 to support APTS infrastructure, research and development, and project management, along with matching state funds totaling almost $300,000. Therefore, netting out APTS expenditures, other capital expenditures by CCRTA during this five-year period would have been closer to $3.9 million.

Table 2.7 CCRTA Capital Expenditures
1996-2000

	Five-Year Total	Annual Average	Percent
By Expenditure Type			
Rolling Stock	$3,426,087	$685,217	68%
Facilities and Other	$1,633,082	$326,616	32%
Total	**$5,059,169**	**$1,011,834**	**100%**
By Source			
Local	$374,844	$74,969	7%
State	$1,367,306	$273,461	27%
Federal	$3,317,019	$663,404	66%
Total	**$5,059,169**	**$1,011,834**	**100%**

Source: National Transit Database.

A review of CCRTA capital program budgets suggests that most of the capital expenditures for "facilities and other" were related to the design and construction of the Hyannis Intermodal Terminal. This facility will provide a centralized, comfortable, and convenient transfer point among local and regional bus routes, a park-and-ride lot, and a new operations center for CCRTA.

Operating Funding Sources

Funding for CCRTA operations is provided through a variety of sources, including:

- Farebox revenue;
- Federal Section 5307 and 5311 operating assistance (Urbanized Area and Non-Urbanized Area formula funds);
- Congestion Mitigation and Air Quality (CMAQ) program grants, primarily to fund demonstration services for the fixed-route summer trolleys;
- The federal Access to Jobs program;
- State contract assistance (operating funds to Regional Transit Authorities);

- "Fully funded" (100 percent reimbursement) contracts with human service agencies (this revenue source declined in SFY 1999 through 2001 due to a shift in HST responsibilities to other transportation service providers, but will increase again in SFY 2002);
- Local assessments to towns on the Cape; and
- Other agency-generated sources such as advertising, interest income, trolley rental, and local service contracts such as with the Falmouth Hospital.

Table 2.8 provides an overview of CCRTA operating funding sources for the last four years for which actual budgets are available (SFY 1998 through 2001). Table 2.9 summarizes the percent of operating funds by source. In SFY 2001, federal funds accounted for 12 percent of operating revenues, state funds for 44 percent, and local funds for 15 percent. Farebox revenue accounted for seven percent while other agency-generated revenue accounted for the remaining 21 percent.

Table 2.8 CCRTA Operating Funding Sources

	1998	1999	2000	2001
Farebox[1]	$ 274,059	$ 306,474	$ 311,846	$ 354,743
Section 5307 – Urbanized Area Formula	135,720	195,000	255,604	331,666
Section 5311 – Non-Urbanized Area Formula	182,908	184,737	184,000	184,000
Congestion Mitigation and Air Quality	156,146	102,194	89,506	51,903
Access to Jobs	0	25,086	62,515	38,655
State Contract Assistance	1,389,102	1,439,121	1,712,539	2,227,787
Fully Funded	1,383,648	1,010,057	564,219	569,305
Local Assessment	581,905	713,882	659,488	768,104
Other[2]	216,544	118,209	476,977	508,253
Total	**$4,320,032**	**$4,094,760**	**$4,316,694**	**$5,034,416**

[1] In the National Transit Database, farebox revenue includes reimbursements from human service transportation providers (shown here under "fully funded" and part of "other"). Farebox revenue shown here includes only the actual fare revenue received from passengers on fixed-route and general demand-responsive services.

[2] "Other" includes advertising, interest income, local service contracts, and trolley rentals.

Table 2.9 Percent of CCRTA Operating Revenues by Source

	1998	1999	2000	2001
Farebox Revenue	6%	7%	7%	7%
Federal Funds	11%	12%	14%	12%
State Funds	32%	35%	40%	44%
Local Funds (Towns)	13%	17%	15%	15%
Other Agency Generated Revenue	7%	28%	24%	21%
Total	**100%**	**100%**	**100%**	**100%**

3.0 Project Description

This section provides an overview of the APTS project and its implementation history, including operating procedures prior to APTS deployment, local goals and objectives for the APTS, elements and chronology of APTS deployment, a summary of the system and its costs as ultimately implemented, related activities, and planned future activities.

3.1 Operations Prior to APTS Deployment

CCRTA operations prior to APTS deployment (i.e., in the mid-1990s) were characterized by the following:[1]

- Five dispatchers at the CATS operations center used personal computers with a DOS-based paratransit scheduling software that had been custom-developed for CCRTA in the early 1980s. The dispatchers registered paratransit customers, scheduled trips, coordinated paratransit and fixed-route operations, and assisted with administrative tasks.
- Dispatchers carried out communication with fixed-route and paratransit vehicle operators via voice radios, transmitting on a 450 MHz channel.
- Customers were required to call the operations center by 11:00 of the day prior to their trip to schedule a trip. Occasionally, trip requests could be accommodated after the 11:00 deadline; the dispatcher needed to call the vehicle operator on the day of the trip to check if the trip could be accommodated.
- Dispatchers assigned trips scheduled for the same area and timeframe to specific operators. Paratransit trip manifests were distributed in hard copy, by facsimile and pick-up, on the afternoon of the day prior to the scheduled trips. Operators created their own routes to serve the trips listed on the manifest.
- Data tracking – including passenger boardings/disembarkings, paratransit pick-ups and drop-offs, and vehicle mileage, fuel, and oil – was performed by vehicle operators on paper log and tally sheets, then entered into spreadsheets at the office by administrative staff.

[1] While this description is written in the past tense, many of the characteristics still describe current operational procedures.

- Paratransit clients were billed monthly for services used, based on trip scheduling records. Fixed-route customers paid cash fares or purchased multi-ride punch cards from vehicle operators.

- Customers could obtain information by calling the operations center. If the question involved real-time location of a vehicle (e.g., a question about a paratransit pick-up), the dispatcher would radio the operator to identify their location.

3.2 Pre-APTS Activities

A number of activities undertaken in the mid-1990s helped to set the stage for the Cape Cod APTS project by making recommendations that supported the concept of the project or its specific components.

- **ITS Feasibility Study –** In 1995, the Federal Highway Administration (FHWA) funded an ITS field operational test feasibility study for the region.[2] The study highlighted the importance of traveler information as one of the primary ITS-related needs on the Cape. The study recommended development of ITS infrastructure and operational testing in four modules: 1) a Travel Information Center, 2) a Tourist Information Center, 3) a Transit Management Center, and 4) a Smart Card Settlement Center. The Transit Management Center concept included an AVL system for tracking bus location; a central operations center; and provision of traveler information through various media. The Smart Card Settlement Center concept included an open-systems stored-value or debit card that could be used for all manner of transactions on the Cape, including transit service. Use of such a card would allow for various incentives to travelers, such as discounts for using transit during periods of peak traffic congestion. The Cape Cod APTS project as it exists today incorporates many of the elements of the proposed Transit Management Center and some elements of the Smart Card Settlement Center.

- **Geographic Information Systems Decision Support Service Grant –** In 1996, the FTA, through its Small Business Innovative Research (SBIR) program, funded the Viggen Corporation to develop a GIS Decision Support Service (GIS/DSS) Environment, using CCRTA as a prototype. This project, completed in 1998, was important in defining the spatial role of AVL data and the role of GIS in integrating spatial data from the AVL and other sources.

---

[2] Farradyne Systems, Inc. *The Application of Intelligent Transportation Systems for Recreational Travel*. Prepared in cooperation with the Massachusetts Highway Department and the Cape Cod Commission for U.S. Department of Transportation, Federal Highway Administration, September 1995.

- **Coordination of Transportation Services –** In 1996, the Department of Agriculture funded the Community Transportation Association of America to conduct a study to recommend coordination of the transportation services in the rural lower Cape Cod area. The study recommendations supported many of the proposed applications of APTS in the Cape Cod APTS project.
- **Intermodal Transportation Center –** In 1996, the 104th Congress provided a legislative earmark for the construction of an Intermodal Transportation Center in Hyannis at the center of the region. This facility was completed in November 2002. CCRTA administrative functions are now located in this center.

3.3 APTS Deployment History and Components[3]

The Cape Cod APTS project was initiated through a partnership between the Cape Cod Regional Transit Authority and the Moakley Center for Technological Applications at Bridgewater State College. This partnership was lead by Lawrence J. Harman, a senior researcher at the Moakley Center; CCRTA Assistant Administrator Dennis Walsh; and William Williamson, General Manager of Cape Area Transportation Systems, Inc. These people had previously collaborated on innovative service initiatives for transit on the Cape and saw the potential value of ITS in this rural tourist environment.

Subsequent to publication of FHWA's ITS feasibility study, CCRTA, the Moakley Center, and the Viggen Corporation formed a public-private partnership to develop what they named the CC_APTS project. An application for the project was submitted to the U.S. DOT's Joint Program Office through the FTA in April of 1997. In October of 1997, the Secretary of the U.S. DOT announced the award to CCRTA of the nation's first application of Rural Transit APTS.[4] In November, CCRTA, Bridgewater State College, and the Viggen Corporation executed agreements for project management and systems integration to launch the project. Mr. Harman was named project manager, joining a project management team that included Mr. Walsh and Mr. Williamson.

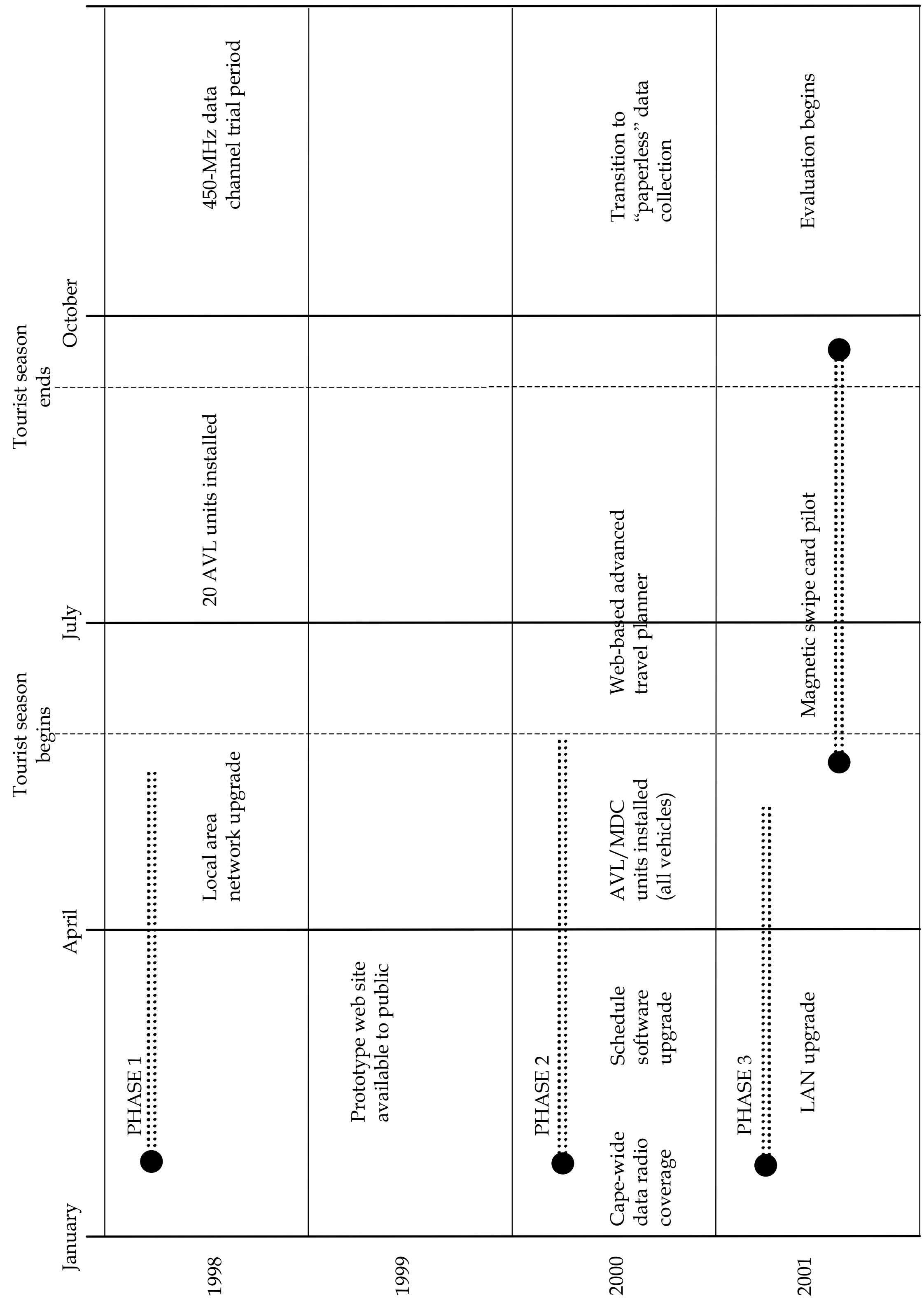
Phase 1 of the project included system design, hardware and software upgrades, and testing of 20 AVL units. Phase 2 included expansion of the AVL and MDC units throughout the fleet as well as expansion of the communications system to cover the entire Cape. A total of three federal grants were awarded for Phases 1 and 2 between 1997 and 1999. Design of the system was initiated in January 1998, with full deployment of Phases 1 and 2 achieved by June 2000. Figure 3.1 illustrates the timeline of APTS project development over this period.

---

[3] The history of APTS deployment as described here is primarily drawn from progress reports submitted by Lawrence Harman and Dennis Walsh.

[4] MA-26-7031-00.

Figure 3.1 Cape Cod APTS Implementation Timeline



Local Goals and Objectives

Staff at CCRTA and the Moakley Center identified seven main goals for implementation of transit ITS on Cape Cod.[5] These goals included:

1. **Improving dispatching operations.** CCRTA expected that receiving and displaying accurate vehicle locations would enhance the operations of the CCRTA fleet. Dispatchers would have the ability to track a vehicle, compare its location to a prescribed route and time point, and advise an operator of late or early running on a route. On the basis of this information the operator can make necessary run adjustments. In addition to the field supervisors and the vehicle operators knowing that a vehicle is running off-schedule, the dispatchers would have the ability to see the extent of the problem and how it may impact other routes or blocks.

2. **Reducing the cost per passenger trip.** CCRTA hoped that the ITS technologies would reduce operating costs by moving passengers from paratransit service to fixed-route service, which is less expensive on a per-ride basis and can accommodate additional trips at little or no cost. The Authority has described this goal as achieving "greater efficiency and effectiveness through coordinated service delivery." Primarily, this objective was expected to be accomplished through Phase 3 activities, including the development of fare incentives for the use of fixed-route service and customer information systems. Phase 1 and 2 activities could also help achieve this objective by facilitating route restructuring so that fixed routes could serve additional areas of high paratransit trip density.

3. **Showing that ITS can work for rural transit operations.** CCRTA hoped to show that ITS can work for rural transit operations, both operationally and financially. Project sponsors believe that the cost of an AVL/MDC unit should be under $4,000 in order to be affordable to rural transit operators. It is hoped that the project will demonstrate the cost-effectiveness of APTS technology for rural transit.

4. **Providing better passenger information.** Customer information was to be provided through an on-line customer information system showing the real-time location of vehicles, information about all types of transportation service, including bus and ferry locations and schedules, and trip itinerary planning using off-the-shelf technology. CCRTA hoped to provide more consistent information that promotes ridership on their services.

5. **Promoting open, interoperable systems in ITS.** CCRTA believed that U.S. Department of Transportation will increasingly require that ITS implementations use open system architecture to encourage innovation and interoperability. Open systems

[5] These goals were articulated in 1999, when evaluation activities for the Cape Cod APTS project were first being planned.

architecture maximizes the ability of the transit agency to maintain the system and make use of its data in-house, thereby reducing costs and increasing flexibility.

6. **Enhancing the amount and quality of the data available for planning and analysis.** CCRTA saw the advantage of new data that ITS can provide, and considered the collection and analysis of these data one of the objectives of implementing ITS technologies. CCRTA believed that their existing scheduling and decision-making capabilities have been fairly effective in addressing the immediate needs of an organization of their size. However, they wanted to obtain more extensive data to gain a historical perspective on their operations. This would allow CCRTA to analyze their operations over time and make strategic, long-term plans for transit on Cape Cod.

7. **Improving safety and security for transit operators and customers.** CCRTA saw improved safety and security for transit operators and customers as one of the primary objectives of ITS in their operations. Their service area is rather large, and most of their vehicles do not operate on fixed routes. The ability of AVL to pinpoint the location of any vehicle in their fleet would provide them with an additional security feature that they believe will make their operations safer.

Activities

The amount of the initial JPO grant award in October 1997 was $200,000. At the same time, CCRTA successfully applied for a CMAQ bus replacement grant, administered through FTA,[6] that included $133,092 for purchase of Phase 1 of the GPS/AVL bus tracking system.

The tasks carried out under these initial grants included:

- **Local Area Network (LAN) –** As a part of the SBIR GIS/DSS project, the Viggen Corporation designed a LAN for the CCRTA prototype GIS environment. To support the APTS project, the project team revised the plan to provide a very robust, fault tolerant, fast, LAN suitable for a full-featured APTS deployment. Dell Computers provided 14 Opti-Plex 266 MHz PCs and two Power Edge 2200 servers with 27 GB hard drives in a RAID 5 configuration. A separate solicitation was developed for 100 Mbps LAN hardware and wiring for the administrative offices and operations center. Hinkley Electronics, a local small business, wired the LAN. After failure in the main server's RAID 5 Controller card in the first week of operation, the LAN was redesigned with a third LAN server independent of the two high-capacity applications servers for GIS and GPS. Bridgewater State College took the lead in procuring the computer hardware through the Massachusetts Higher Education cooperative purchase contract.

[6] MA-90-X286-00.

- **Paratransit Scheduling Software –** Initially, a contract was awarded to a private vendor, Multisystems, Inc., for a scheduling software program. However, during the procurement process, some concerns regarding data interchange and data accessibility with this software arose that conflicted with the project management's philosophy of open systems. The contract was therefore terminated in April 1998. Instead, CCRTA's existing, custom-built paratransit scheduling software was installed on the new LAN. This software was initially developed in the early 1980s. In winter 2000, the software was upgraded by its original author to a relational database Windows environment and with a report structure compatible with MDC requirements.

- **GIS/Customer Information Systems (CIS) –** The project team initially intended to procure a GIS/CIS system from the same vendor as the paratransit scheduling software. However, this procurement also was terminated due to open systems concerns. Instead, a Viggen analyst procured Maptitude for the Web for CCRTA and prepared this for use on CCRTA's web site in conjunction with AVL data. The mapping application was placed on a new computer server at the Moakley Center at Bridgewater State College. Beta testing began in summer 1998.

- **Communications –** The Viggen Corporation contracted with a communications specialist to review the existing CCRTA two-way radio system and make recommendations for an APTS communications system.[7] A primary objective was to conduct a limited demonstration of the AVL for the summer of 1998 without precluding the long-term requirements of AVL for all modes and extensive use of MDCs and electronic fare media in the future. The report identified the most cost-effective long-term communications option to be the establishment of a separate 450 MHz channel for data transmission, which would be used in addition to the existing voice radio channel. The Yarmouth Fire Department agreed to make its 450 MHz radio license available to CCRTA for trial use for a six-month period beginning in fall 1998.

  A similar communications study conducted for the neighboring Greater Attleboro Taunton Regional Transit Authority indicated the advantages of cellular digital packet data (CDPD), a public network, to serve the needs of a service area extending beyond the Cape. CDPD was used for the initial deployment of 20 AVL units during the summer of 1998, prior to installation of the dedicated 450 MHz channel. However, the CDPD alternative ultimately was not utilized because of the high per-unit cost of data transmission, which would have made providing real-time information on the location of buses (transmission intervals of less than five minutes) cost-prohibitive.

- **GPS/AVL Units –** Specifications for the AVL were developed by Viggen Corporation, based in part on the communications requirements identified. A request for proposals for GPS/AVL units was published in February 1998. An award was made to Raytheon – Transportation Management Solutions (TMS) in April 1998 for the Phase 1 deployment of 20 GPS/AVL units. These were deployed in July and August 1998, on

[7] Lightwave Spectrum International, Inc. *Automatic Vehicle Location System – Communications Infrastructure Alternatives.* January 1998.

all community and regional bus routes and trolley services, and a few paratransit vehicles. In October 1998 they were reinstalled in paratransit vehicles, then reinstalled in the seasonal trolley vehicles for summer 1999. In October through December 1998, Raytheon completed installation of 20 data radios and modems linked to the GPS/AVL units.

Phase 2[8]

Phase 2 of the APTS project was funded through a third FTA capital grant, awarded in March 1999,[9] that included $448,000 for the design, purchase, and installation of additional APTS components. Phase 2 focused on completion of the communications system recommended in Phase 1; full deployment of integrated AVL and MDC units on all CCRTA buses; upgrading the paratransit scheduling software; and developing Internet-accessible customer information utilizing the AVL data.

- **Local Area Network –** The CCRTA LAN underwent a major upgrade between January and June 2001, with installation of two new servers and optimization of the network. An ISDN connection was installed between the operations center and administrative headquarters, allowing administrative staff to view AVL data and query the AVL/MDC database.

- **Communications –** The Phase 1 AVL mobile units were deployed on summer shuttle routes on a dedicated data radio frequency for the 1999 summer tourist season. This radio system used the Yarmouth Fire Department's 450-MHz channel that the Yarmouth Fire Department agreed to make available to CCRTA for AVL purposes. The data radio was extended for optimum coverage (99 percent of the area, 99 percent of the time) throughout the Cape region through the purchase and installation of data radio base stations for the eastern and western portions of Cape Cod by spring 2000. The radio communications system is a two-frequency system (one for voice and one for data), with two antennas on each of three towers, which are located in Falmouth, Yarmouth, and Orleans. While the existing voice radio communicates between the towers and operations center via microwaves, the new data channel communicates via dedicated lease line wires. Wire connections were selected because they required a smaller capital investment than a microwave system; however, they do incur some annual maintenance costs.

---

[8] This section is drawn largely from: Walsh, Dennis T. *Cape Cod Advanced Public Transportation System: A Full-Featured Transit ITS Deployment In A Small Urban and Rural Tourist Economy*. Paper presented at the 14th National TRB Rural Public and Intercity Bus Transportation Conference, *Rural Mobility Solutions for the 21st Century*, Lake Tahoe, Nevada. November 13, 2000.

[9] MA-90-X294-01.

- **AVL/MDC Units –** An evaluation of the Phase 1 AVL deployment led to the decision not to exercise the Phase 2 and 3 AVL option to build out with Orbital Sciences TMS (nee Raytheon TMS). The project design was revised to specify an integrated AVL/MDC solution with integrated electronic messaging and fare payment capabilities to better accommodate the demands of paratransit operations, and that also could provide AVL for fixed-route services at lower cost. In fall 1999, Mentor Engineering of Calgary, Canada was selected for Phase 2 and 3 to deploy their integrated AVL/MDC, which also includes a reader for electronic fare payment systems. CCRTA participated in a cooperative purchase process for the AVL/MDC units with neighboring GATRA, purchasing 100 units for its own fleet. The AVL/MDC units were deployed on fixed-route vehicles in May through July 2000, and on paratransit vehicles extending from May 2000 through January 2001.

- **AVL/MDC Host Software –** The host software for the AVL/MDC system was designed by TriStar Software, Inc., a subcontractor to Mentor Engineering. The software was installed and training conducted over the course of May 2000 through January 2001, consistent with the installation of the AVL/MDC units.

- **Paratransit Scheduling Software –** CCRTA's existing paratransit management software, written in General Business Basic, was upgraded to Microsoft SQL on an NT Windows LAN server. File structure requirements for downloading vehicle manifests to mobile data terminals were defined by CCRTA for MDC deployment during the summer/fall of 2000.

- **Customer Information –** CCRTA and the GeoGraphics Lab at the Moakley Center developed a real-time AVL web-based GIS mapping prototype on the GeoLab web server.[10] Beta testing was conducted from July 1998 through early 1999. The application was made available to the public by March 1999 via CCRTA's dial-up Internet Service Provider. It can be viewed at www.e-transit.org.

Phase 3[11]

Phase 3 of the Cape Cod APTS focused on the demonstration of electronic payment systems (EPS). The CCRTA regional bus, community bus, summer trolleys, and demand-responsive vehicles were EPS-ready by the fall of 2000 with the installation of integrated AVL/MDCs and the build out of a regional dedicated data radio system. A two-year

---

[10] This mapping application was developed in conjunction with an Advanced Travel Planner (ATP), described in Section 3.5, which was developed through the FTA Jobs Access and Reverse Commute (JARC) program. The use of the ATP for JARC purposes is not a subject of this evaluation.

[11] While not formally a subject of this evaluation, some Phase 3 activities were implemented prior to the period of performance of this evaluation, and therefore are noted because they may be reflected to some extent in CCRTA staff's assessments of the system to date.

CMAQ grant[12] was received in March 2001 to provide user-side subsidies using electronic payment systems to promote increased use of transit on the Cape, with the objective of addressing summer traffic congestion and air quality issues. The grant included $120,000 in capital funds for design, purchase, and construction of EPS-related equipment, including cards, card readers, and communications equipment upgrades, and $200,000 in user-side subsidies to support demonstration of the EPS.

Phase 3 funded the Cape Cod Transit Tourist Pass (CCTTP) demonstration program in summer 2001, which was undertaken in cooperation with the Cape Cod Chamber of Commerce. This program was continued and expanded during the summer of 2002, the second year of the CMAQ grant. Under the program, hoteliers located within one-quarter mile of a CCRTA fixed-route and having Internet capabilities were recruited to participate in a demonstration of electronic fare media. Participating hotels received passes to distribute free for their guests to use transit during their visit to Cape Cod. Each participating hotel was required to enter a minimal amount of information for each guest receiving a pass. In return for their effort, the hotels also were allowed to provide the passes for the use of their employees. The user of the pass would give the pass to the bus operator upon boarding and disembarking, and the operator would insert the pass into the card reader in the MDC terminal head. The program provides CCRTA with information on the use of the cards, including boarding and alighting time and location as well as the home location ZIP code of card users.

■ 3.4 Summary of APTS Phase 1 and 2 as Implemented

Funding Sources

Table 3.1 lists the sources used by CCRTA to finance the APTS project, grant information, and the use of each source. Table 3.2 summarizes Phase 1 and 2 funding by source. For Phase 1 and 2 activities, approximately 16 percent of funding came from the initial ITS/JPO demonstration grant, 46 percent from CMAQ funds which were flexed to transit, and 26 percent from State Section 5310 funds (Elderly and Persons with Disabilities) used as the required local 20 percent match for the federal funds. The remaining 12 percent came from CCRTA Section 5311 funds (Non-Urbanized Area Formula), which are normally used to subsidize paratransit operations. The Section 5311 funds were used to cover the time of the operations staff responsible for project implementation.

---

[12] MA-90-X355-00.

Table 3.1 Summary of Grants Received for APTS

Grant Title	Funding Source	Title/Component	Primary Uses	Date Awarded	Amount of Award	Details
Phases 1 and 2						
FTA Grant MA-26-7031-00	JPO/§5314(a)	§5314(a) Research and Training funds for Rural ITS Demo.	Implement LAN; develop communications requirements; develop GPS/AVL and MDC specifications; upgrade communications; procure GIS/CIS; upgrade paratransit scheduling software	Sept. 1997	$200,000	Travel – $10,000 Equipment – $90,000 Consulting – $100,000
FTA Grant MA-90-X286-00	CMAQ/§5307	GPS/AVL Bus Tracking System (Scope 116-00)	Procure and install 20 AVL units	Sept. 1997	$133,092	
FTA Grants MA-16-0023, MA-16-0024	State/§5310		Local match for Federal grants		$54,960	
A2J-FY99	State/§5310		Local match for Federal grants		$50,250	
RTACAP	State/§5310		Local match for Federal grants		$222,648	
	CCRTA/§5311		Section 18 operating funds for operations staff time		$150,000	
FTA Grant MA-90-X294-01	CMAQ/§5307	Design, purchase, and construct signal and communications equipment (fleet management and traveler info)	Procure and install 100 AVL and MDC units, plus software and workstations; complete communications upgrade; second LAN upgrade	March 1999	$448,000	Design – $37,600 Purchase – $354,400 Construct – $56,000
Subtotal, Phases 1 and 2					**$1,258,950**	

Table 3.1 Summary of Grants Received for APTS (continued)

Grant Title	Funding Source	Title/Component	Primary Uses	Date Awarded	Amount of Award	Details
Phase 3						
FTA Grant MA-90-X355-00	CMAQ/§5307	Demonstration of Cape Cod Smartcard	Design, purchase, implement EFP cards and equipment	March 2001	$120,000	Design – $30,000 Purchase – $50,000 Construct – $40,000
FTA Grant MA-90-X355-00	CMAQ/§5307	Demonstration of Cape Cod Smartcard	User-side fare subsidies	March 2001	$200,000	
Subtotal, Phase 3 – Capital					**$120,000**	
Subtotal, Phase 3 – Operating					**$200,000**	

Table 3.2 APTS Phase 1 and 2 Funding Sources

Source	Total	Percent
Joint Program Office/Section 5314(a)	$ 200,000	16%
Congestion Mitigation and Air Quality/Section 5307[1]	596,428	48%
State/Section 5310[2]	286,753	23%
CCRTA/Section 5311[3]	150,000	12%
Total	**$1,233,181**	**100%**

[1] Urbanized Area Formula.

[2] Elderly and Persons with Disabilities.

[3] Non-Urbanized Area Formula.

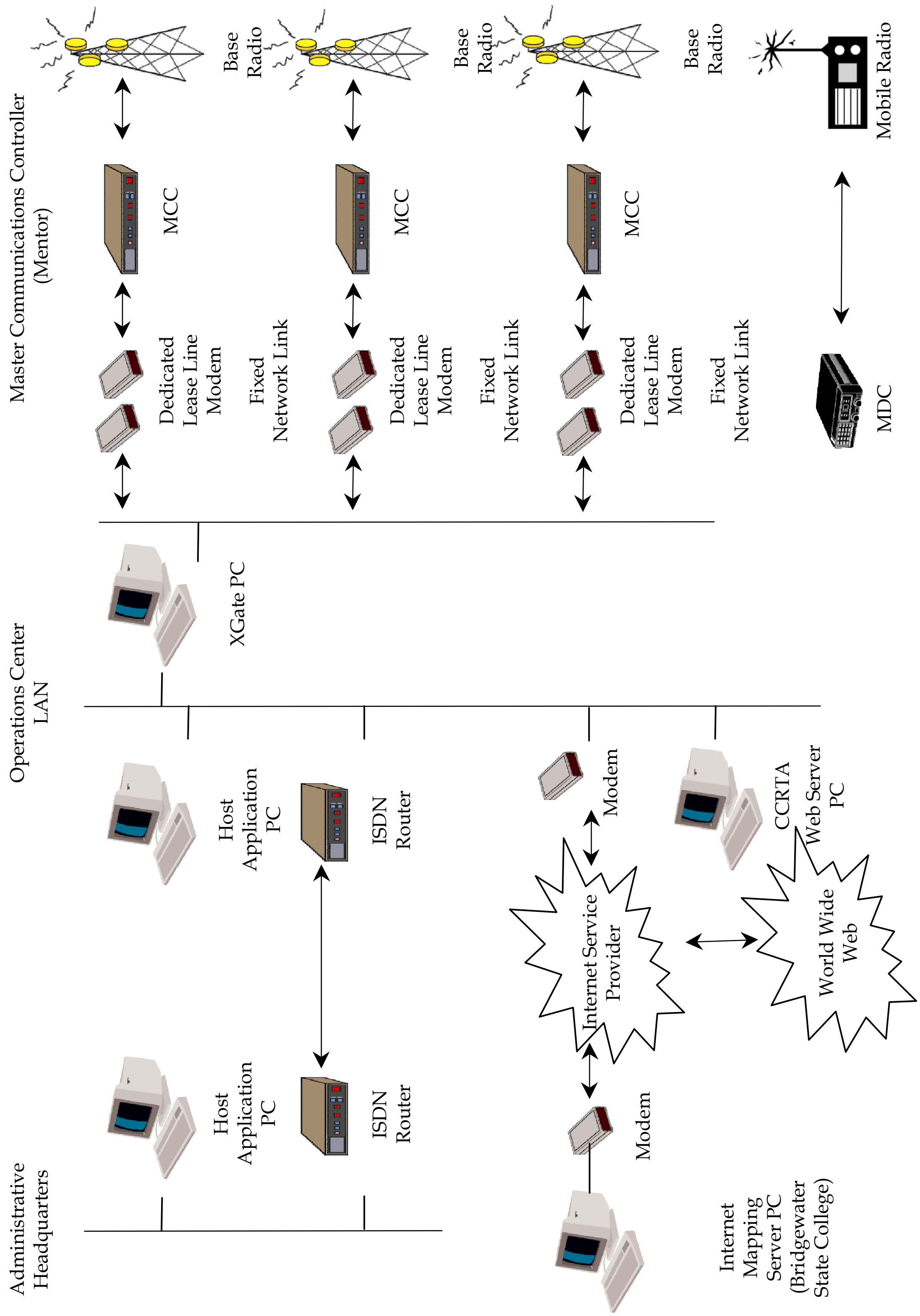
CCRTA estimates that the $150,000 taken from Section 5311 funds represents only about half of the total value of staff time spent by administrative and operations staff on the APTS project. However, total staff time spent on the project cannot be estimated precisely, as nearly all staff worked on the project at one time or another and time spent on APTS-related activities was not tracked separately from time spent on other activities. Therefore, an estimate of the total capital cost of Phase 1 and 2 *not including* any CCRTA staff time would be $1,083,181; including the full value of CCRTA staff time, this estimate would rise to about $1.38 million.

System Architecture

Figure 3.2 diagrams the communications architecture for the AVL/MDC system. The AVL/MDC host application resides on PC workstations at the CCRTA operations center and administrative headquarters. The host application communicates over the local area network with the communications software located on the AVL/MDC server. The server communicates with three master communications controllers, one for each radio tower, via dedicated lease line modems. The radio towers communicate with the MDCs via the mobile radio on each bus.

While the AVL/MDC servers are located at the operations center, staff at administrative headquarters can access the AVL/MDC databases and view data over an ISDN connection between the two offices. While more expensive than a dial-up connection, the ISDN connection allows administrative staff to access data and provide quality central oversight of operations. An Advanced Travel Planner (ATP), which includes an Internet mapping web site, is hosted on a server at Bridgewater State College. This web site links to CCRTA's site (hosted at the operations center) which has schedule and route information. The server at Bridgewater State College retrieves AVL data every 60 seconds from the operations center via an open dial-up connection, using software designed by Viggen Corporation.

Figure 3.2 Communications Architecture



Software

There are four software components that work together to support the AVL and MDC:

1. The AVL/MDC host application;
2. The paratransit scheduling software;
3. The communications software; and
4. Internet mapping software.

AVL/MDC Host Application

Developed by Mentor's subcontractor TriStar Software, Inc., the host application is a Windows-based application written in Visual Basic. The host application includes the following functionalities for dispatchers:

- Viewing and monitoring the status of fixed routes and paratransit routes (e.g., whether an operator has signed on or off and current passenger load);
- Viewing a map of the Cape transit service area, streets, and real-time locations of buses. The view characteristics of the map can be edited and the map can be used for address lookup;
- Replaying historical AVL data to trace a buses' path;
- Controlling the selection of communications towers and communications status with specific buses;
- Sending a message to a bus or receiving a message (via a pop-up window); and
- Sending manifests to buses.

The AVL/MDC host application also includes the following additional functions for administrators:

- Adding, modifying, or deleting data regarding employees, buses, and routes;
- Matching operators, buses, and routes for daily assignments;
- Generating standard reports from the database, such as mileage, fuel, and oil by vehicle or passenger-trips by route and day.

Paratransit Scheduling Software

The paratransit scheduling software is a computer-aided dispatch system that was developed roughly 20 years ago for CCRTA as public domain software, written in General Business Basic for a DOS environment. The software was upgraded in 1998 to a Windows 2000 environment, written in Microsoft Special Query Language (SQL), by a local programmer and renamed "Transit for Windows." The cost of these upgrades was covered by Human Service Transportation (HST) and APTS project grants and were a necessary component to utilize the capabilities of the AVL/MDC system.

The paratransit scheduling software allows dispatchers to enter and edit client information (name, address, and other characteristics) and trip information (e.g., date, origin, destination, pick-up and drop-off time, and program served if applicable). Client and trip records are stored in separate databases.

While distinct from the AVL/MDC host software, both the host software and the paratransit scheduling software use shared databases on the same server, including the customer information database and trip database, as well as the actions table and GPS table from the AVL/MDC.

Communications Software

The communications software, XGate 2.0, was developed by Mentor Engineering, Inc. This software serves as the link between the AVL/MDC host application and the Mobile Data Computers, sending messages between the operations center and MDCs. XGate 2.0 has three windows, which display the current status of each MDC unit, the status of radio communications, and the dispatch link status (i.e., connection with the dispatch software).

XGate requires a Microsoft Access database linking MDC unit identification numbers to bus identification numbers. XGate populates two Access databases, the Actions Table and the GPS Table, with data transmitted from the MDCs. XGate also creates log files that are used for debugging any problems that might occur. XGate can be used by the system administrator to control communications, e.g., to set the intervals at which messages are re-sent if the target MDC is not responding.

Internet Mapping Software

Maptitude's Internet mapping software, Maptitude for the Web, is used to display a map of the CCRTA service area with real-time location of buses. This application is hosted on an Internet server at the Moakley Center.

3.5 Other Related Activities

The following activities are not explicitly a part of the Cape Cod APTS Phase 1 and 2 implementation; however, they complement the APTS system by extending the benefits of traveler information systems developed for this project.

- **Advanced Travel Planner –** CCRTA and the GeoGraphics Lab at the Moakley Center cooperated on the development and deployment of a web-based Advanced Travel Planner (ATP) using state-of-the-art GIS technology applied to tourist travel information and itinerary trip planning for access to jobs for individuals transitioning off welfare. The ATP is integrated with the AVL mapping application described above. The ATP allows users to enter an origin address and a destination address. The ATP then plots these locations on a map of the Cape that includes bus routes. Users can click zoom and pan on the map, or can click on a bus route to obtain fare and schedule information for that route. The ATP was first made accessible to the public in summer 2000 and is located at www.e-transit.org. Its development was funded by two FTA Jobs Access and Reverse Commute grants totaling $332,000.

- **Extension to Regional Transit Carriers –** An application for rural intercity bus capital assistance [S.5311(f)] was filed to add AVL/MDCs for all intercity buses providing service from Provincetown, to the urbanized area of Hyannis, through Plymouth, and on to metropolitan Boston and Logan International Airport. The AVL portion would have used regional public CDPD networks and provide customers with vehicle locations through the CCRTA Transit Management Center and the GeoGraphics Labs World Wide Web server. However, this proposal was unilaterally withdrawn by the intercity carrier after approval of a grant for FFY 2000. Currently, GATRA has purchased AVL units and is negotiating a contract with Mentor for MDCs. GATRA also is evaluating a paratransit scheduling software package produced by Multisystems, Inc.

3.6 Planned Future Activities

CCRTA and Moakley Center staff have envisioned the following future extensions and enhancements of the APTS system, contingent upon funding and the availability of technical resources:

- **Expansion of Electronic Fare Payment –** A significant long-term objective of the Cape Cod APTS project is the development of electronic fare payment systems. The objectives are both to reduce administrative burden associated with manual fare payment (especially billing of paratransit clients), and to allow greater flexibility in fare schedules – for example, to provide fiscal incentives for paratransit clients to shift to fixed-route services where such services are available.

- **Extension Throughout the Region –** Cooperative efforts are underway with interregional carriers to the Cape and Islands (Nantucket and Martha's Vineyard) to develop an interregional intermodal interline electronic payment system in the future.

- **Expanded Customer Information Opportunities –** Currently, real-time information on the location of CCRTA buses is available to the customer only via the Internet or by calling the operations center. Future plans call for deploying information kiosks at selected locations, including an intermodal transportation terminal under construction in Hyannis. Applications for distributing information via cell phone or personal digital assistant (PDA) also are being considered.

- **Estimated Time of Arrival Algorithm –** Researchers at the Moakley Center have been developing an estimated time of arrival (ETA) algorithm that predicts the arrival time of buses based on historical and current patterns. This information will initially be distributed via the web site and information kiosks, and then by other means as other information channels are developed.

4.0 Evaluation Goals, Measures, and Hypotheses

The National ITS Program has identified a set of goals for ITS projects along with "a few good measures" associated with each goal area.[1] The purpose of these measures is to establish consistency and focus across evaluations of a wide range of ITS projects. These goals represent "outcomes" of interest to society, such as changes in service cost and travel times. The goals include:

- **Safety –** Measured through a reduction in crash rates;
- **Mobility –** Measured through reduction in delay and travel time variability, as well as improvement in customer satisfaction;
- **Efficiency –** Measured through increases in throughput or effective capacity, as well as congestion relief;
- **Productivity –** Measured through cost savings; and
- **Energy and Environment –** Measured through reductions in emissions and energy consumption.[2]

The National ITS program also identifies a "few good measures" associated with each goal area. The purpose of these measures is to establish consistency and focus across evaluations of a wide range of ITS projects. Alternative or surrogate measures also may be defined based on the available data and expected benefits for a specific project. The evaluation plan for the Cape Cod APTS project defines alternative measures that relate to the National ITS "few good measures" but are also specifically relevant to the current

---

[1] U.S. Department of Transportation. *Transportation Equity Act for the 21st Century; Guidelines for the Evaluation of Operational Tests and Deployment Projects for Intelligent Transportation Systems (ITS).* Published in the Federal Register, Vol. 64 No. 181, September 20, 1999.

[2] Project sponsors identified four of the goal areas – safety, mobility, efficiency, and productivity – as directly relevant to the Cape Cod APTS project. Although the project may have some energy and environmental benefits, these goals are not specifically addressed in this evaluation, with the exception of emissions benefits evaluated from the Phase 3 tourist transit pass program (see Appendix B).

transit ITS project.[3] The evaluation plan further identifies a set of hypotheses associated with each goal area, describing specifically how the Cape Cod APTS project is expected to have an impact in each area.

The remainder of this section reviews the goals and measures established by the National ITS Program as well as the surrogate measures and hypotheses established in the evaluation plan. It then describes the methodology used to conduct the evaluation.

4.1 Goals of the National ITS Program

Safety

The National ITS Program identifies improvements to safety as an important goal of ITS projects. In the transit context, safety improvements mean improvements in the response to emergency incidents on transit vehicles involving either passengers or drivers. When a transit vehicle is involved in an accident, ITS technologies such as AVL can help identify the exact location of the vehicle, and thus speed the required emergency services to that location.

Mobility

The National ITS Program outlines mobility goals in terms of travel time improvements and increased customer satisfaction. Travel time improvements include both the reduction in overall travel time for passengers as well as the reduction in the variability of travel times so that passengers can better predict how long a trip will take. In addition to time savings, the provision of better information to travelers regarding travel options and anticipated waiting/travel times also can be considered a mobility benefit.

The national goals are directly relevant to the Cape Cod APTS project. Transit travel time benefits may include three components: 1) the average time it takes for a given trip; 2) travel time variability, as measured by on-time performance or schedule adherence; and 3) for paratransit, the advance time needed to schedule a transit trip. Reductions in travel time variability also can be measured through the size of the pick-up window required for paratransit trips. Qualitative or quantitative measurement of customer satisfaction can further describe the benefits of improved travel information and quality of service to transit customers.

---

[3] Casey, Robert F., Christopher D. Porter, Laurie Hussey, and Thomas Buffkin. *Evaluation Plan for the Cape Cod Advanced Public Transportation System.* Prepared for the U.S. Department of Transportation, RSPA/VNTSC-WP-TT050-1, June 2000.

An additional transit-relevant measure of mobility is transit system utilization. An increase in the number of passenger-trips suggests that people are provided with – and taking advantage of – greater mobility options. In the transit context, the recent access to jobs initiative has placed an emphasis on providing work-trip opportunities for low-income and/or mobility-limited clients.

Efficiency

The National ITS Program specifies that ITS projects should improve efficiency of transportation services. Efficiency can be defined generically as output per unit of input. Often applied to the highway context, increased efficiency is defined in the National ITS Program goals to mean increased throughput or effective capacity, as well as reduced congestion. Effective capacity is the maximum potential rate at which persons or vehicles may traverse a link or node under a representative composite of operating conditions. Throughput is defined as the number of persons or vehicles actually traversing a section of the transportation network per unit time.

In the CCRTA transit context, a parallel definition can be established in which efficiency is measured as the number of transit trips served per vehicle-mile or vehicle-hour of service. Improvements in efficiency will be seen when the number of passengers served increases per amount of resources used. Transit system efficiency is tied closely to productivity, and will be considered concurrently with productivity.[4]

In addition to improving transit system efficiency, the Cape Cod APTS also may have impacts on overall roadway system efficiency, if customers can be diverted from personal vehicles to the transit system. Specifically, higher vehicle occupancies (as a result of transit use versus auto use) can result in a higher number of person-throughput per lane-mile of road. This is viewed as a particularly important objective during the peak tourist season, when significant congestion is experienced in many locations on the Cape. The benefits to traffic congestion are a function of the number of people who shift from automobiles to transit.

Productivity

Productivity has been generally defined within the National ITS Program as cost per unit output, e.g., cost of transportation services provided per person-mile of travel. The National ITS Program outlines two ways to calculate the costs savings of ITS. One is to calculate the difference in costs before and after installation of a system. The other is to

---

[4] In fact, in the transit industry, passenger-trips per vehicle-hour is often referred to as productivity, especially in the context of paratransit service. The definitions as outlined here are used for consistency with the National ITS Program goals and objectives.

compare the cost of ITS to traditional transportation improvements that are designed to address the same problem.

In the context of transit, total cost per passenger-trip or passenger-mile can be considered as an overall measure of transit agency productivity. This will be determined both by the cost of providing a unit of transit service (cost per vehicle-hour or vehicle-mile) and the *efficiency* of the service, as defined above (passenger-trips or passenger-miles per vehicle-hour or vehicle-mile). Efficiency will be influenced by increases in driver/vehicle productivity for paratransit and by increases in ridership for fixed-route service. Overall productivity, in turn, will be influenced by the monetary capital and operating costs of the ITS system and by changes in other staff time requirements, notably dispatcher, administrative, and maintenance staff time.

■ 4.2 Evaluation Measures and Hypotheses

Table 4.1 summarizes the National ITS Program goal areas, associated "few good measures," and alternative or surrogate measures proposed for the Cape Cod APTS system. Table 4.1 also includes hypotheses regarding the various benefits of the system.

■ 4.3 Evaluation Methodology

The evaluation plan for this project was developed between June 1999 and June 2000. To develop the plan, an initial set of interviews was conducted with CCRTA and Moakley Center staff to identify available data sources as well as perceived benefits of the project. The evaluation plan was written to focus on Phases 1 and 2 of the APTS deployment, which included development of the LAN, communications infrastructure, GIS decision support system, paratransit software upgrade, and deployment of AVL and MDC units on all vehicles. It did not include Phase 3, which includes testing of electronic fare payment systems.

The actual data collection and analysis for the evaluation was conducted between October 2001 and February 2002. While the evaluation was contracted in spring 2001, for a variety of reasons it was deemed infeasible to actually begin evaluation work prior to the fall of 2001. The evaluation was performed using a combination of quantitative data analysis and qualitative data-gathering via interviews.

Table 4.1 Cape Cod APTS Evaluation Measures and Hypotheses

Goal Area	National ITS "Few Good Measures"	Surrogate or Alternative Measures	Hypotheses
Safety	• Reduction in crash rates	• Reduction in incident response time	• Incident response time will decrease as the ability of CCRTA to locate its vehicles is improved
Mobility	• Reduction in delay • Reduction in travel time variability • Improvement in customer satisfaction	• Average travel time or speed per trip • Advance time required to schedule trip • Schedule adherence • Provision of customer information • Customers/trips served • Customer satisfaction	• Scheduling/routing efficiency will increase, thus: – Reducing trip times – Allowing trips to be scheduled with less advance notice – Decreasing the size of the pick-up window • More customers can be served (for a given cost) as a result of increased operating efficiencies • Customer satisfaction will improve as a result of improved performance and information
Efficiency	• Increases in throughput or effective capacity • Congestion relief	• Passenger trips per vehicle hour • Number of trips shifted to fixed-route transit	• Improved operating efficiencies will increase transit system throughput/capacity • Because of better information, some trips or trip segments can be shifted to fixed-route transit, thus improving systemwide capacity
Productivity	• Cost savings • Job satisfaction	• Staff time per task (calls, scheduling, maintenance, etc.) • Cost per passenger-trip or passenger-mile • Cost per vehicle-hour • Staff acceptance	• Through more effective scheduling, dispatching, and fleet control, the overall staff time requirements and hence cost per unit of service provided will decrease • The APTS technologies will be viewed as beneficial by transit agency staff in assisting them with their jobs

The following quantitative data were obtained from CCRTA and analyzed:

- Monthly ridership, vehicle operating, cost, and farebox revenue data by route (for fixed-route) and town (for paratransit) for 1996 through October 2001;
- Cost estimates of APTS components assembled by CCRTA administrative staff;
- CCRTA capital and operating budgets for FY 1999 through 2001, as well as projected for 2002;
- Archived AVL/GPS data collected during the last week in August for both summer 2000 and summer 2001; and
- A tally maintained by dispatchers for one week during February/March 2002 of calls received by purpose.

To gather qualitative data, interviews were conducted with 17 people. Except as noted, all interviews were conducted in person by Cambridge Systematics staff Chris Porter and/or Lynn Ahlgren. In some cases, multiple interviews were conducted to obtain follow-up information and clarifications. Interviewees included:

- Dennis Walsh, CCRTA assistant administrator;
- Paul Smith, CATS operations manager;
- Thomas MacKenzie, CATS maintenance supervisor;
- Lawrence Harman, senior researcher at the J. Joseph Moakley Center for Technological Applications at Bridgewater State College, and Cape Cod APTS project manager through May 2001;
- William Williamson, general manager of CATS through summer 2000 (by telephone);
- Timothy McCombe, a summer intern from Bridgewater State College and later staff person with CCRTA who oversaw implementation of the Transit Tourist Pass in summer 2001;
- Five dispatchers at the CCRTA operations center; and
- Six bus operators, including three paratransit operators and three fixed route operators.

While nearly all of the dispatchers currently employed at CCRTA were interviewed, the number of operators interviewed (six total) is relatively small compared to CCRTA's full-time staff of 40 to 50 operators. The primary objective of the interviews was to identify how operators used the APTS equipment and major areas of impact on the operators' jobs. Both fixed-route and paratransit operators use the APTS only through the MDCs which are used for data entry and communication. Since the use of the MDCs by operators was relatively straightforward and the operators provided consistent responses, it was concluded that further interviews were not necessary.

The following reports and documents also were reviewed:

- Grant applications for all grants related to the APTS project;
- The report on communications infrastructure;[5]
- Progress reports from Phases 1 and 2 of the Cape Cod APTS project;
- Users' manuals for the MDCs and APTS software;
- CCRTA customer surveys conducted during 1998 and 1999;
- The final report on the Cape Cod Transit Tourist Pass Program for summer 2001;[6]
- A CCRTA report on route restructuring in the Hyannis area, entitled "Hyannis Villager 2001 Summer Service"; and
- Evaluation of CCRTA's implementation of Cape Cod Transit Task Force Summer 2001 Recommendations,[7] which included various service-related recommendations.

The following data sources were identified in the evaluation plan as potential resources, but ultimately not used in the evaluation:

- **Incident Reports –** Only two incidents were identified when the silent alarm was used. Anecdotal evidence was obtained; and no additional value was seen from reviewing the incident reports;
- **Call Tracking System –** Archiving of call tracking data was limited, and only minor if any impacts were expected on delays to customers calling; and
- **Client Database –** No reasons were identified to review this database.

---

[5] Lightwave Spectrum International, Inc. in association with Viggen Corporation. *Cape Cod Regional Transit Authority Automatic Vehicle Location System Communications Infrastructure Alternatives*. January 1998.

[6] Cape Cod Regional Transit Authority, GeoGraphics Laboratory, Moakley Center for Technological Applications, Bridgewater State College and Cape Cod Chamber of Commerce. *Cape Cod Tourist Transit Pass Program – e-transit comes to the Cape*. November 2001.

[7] *Final data evaluation of CCRTA's implementation of Cape Cod Transit Task Force Summer 2001 Recommendations*. Memo from Dennis Walsh to Clay Schofield, March 15, 2001.

5.0 APTS Deployment Results

This section presents findings on the benefits and impacts of the APTS system to the Cape Cod Regional Transit Authority and its customers. First, the ways in which the APTS system are being used on a day-to-day basis by CCRTA employees are described, to provide an understanding of how it has affected CCRTA's operations. Then, the benefits and impacts of the APTS are discussed under various categories, including:

- Operational benefits to CCRTA:
  - Operations management;
  - Data management;
  - New data collection;
  - Safety; and
  - Job satisfaction.
- Costs to CCRTA:
  - Capital costs;
  - Maintenance costs; and
  - Staff time (initial and ongoing).
- Systemwide performance measures:
  - Ridership and farebox revenue; and
  - Service productivity and efficiency.
- Potential benefits to the CCRTA customer:
  - Customer information;
  - Paratransit trip scheduling;
  - On-time performance;
  - Trip travel times;
  - Safety; and
  - Other benefits.
- Potential benefits to others:
  - Vehicle trip reduction/emissions.

After discussing observed impacts to date, anticipated future benefits of the system also are discussed. Finally, technological, institutional, and other issues related to the APTS deployment (such as reliability of the equipment and adequacy of training) are discussed.

5.1 Use of APTS Technology

The APTS equipment, including the MDCs, the AVL system, and interface software, is used on a day-to-day basis by dispatchers and vehicle operators. It also is used routinely by operations management staff who oversee the dispatchers and operators. Both operations management and administrative staff also query the data collected by the MDCs for reporting functions or for analysis purposes.

Dispatchers

CCRTA employs six dispatchers who perform a variety of functions for the Authority, including the dispatching of both fixed-route and paratransit vehicles as well as the scheduling of paratransit trips. Dispatchers use the APTS equipment for two primary functions:

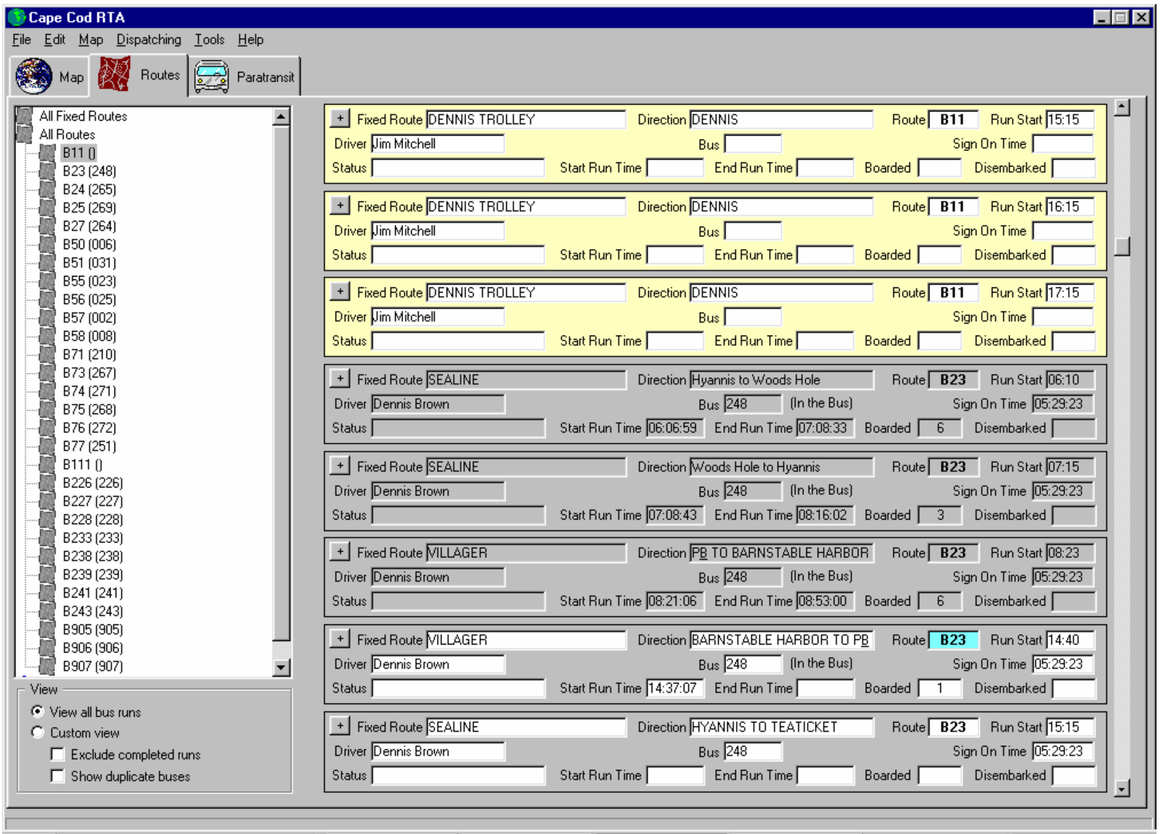
1. **Communication** – Communicating with vehicle operators via electronic messaging to MDCs, in place of voice radio contact or hard copy distribution of trip manifests; and

2. **Operations Oversight** – Using a GIS mapping application to observe the locations of buses either in real-time or replaying past history, to assist in overseeing operations and providing customer information.

The dispatchers use the AVL/MDC host application software to send and receive messages from the operators and track vehicle, operator, and route status. This application also contains a mapping window in which the locations of buses can be viewed in real-time or replayed. Examples of screens viewed by the dispatchers are presented in Figures 5.1, 5.2, and 5.3. Dispatchers also use a locally developed transit scheduling software program, Transit for Windows, to track paratransit trip clients and schedule paratransit trips. Both applications utilize and populate shared databases on the same server. While the Transit for Windows software was developed and implemented prior to the APTS deployment, it is an integral part of the dispatchers' use of the APTS equipment.

Communication between dispatchers and operators takes place through two separate methods: voice radio and the MDCs. The radios installed on CCRTA buses include two channels, one for voice communication and one for data. To communicate via the MDCs, dispatchers type a message which, once sent, appears on the operator's MDC screen. Operators can reply with a yes or no response or with one of seven "canned" messages. In theory, the MDCs provide the first line of communication with the radio being used for only those situations that require operator input greater than a yes/no or canned response.

Figure 5.1 AVL/MDC Host Software: Fixed Route Screen



Note: Highlighted bus runs indicate that the driver has not yet signed on.

Source: TriStar Software, Inc. "Cape Cod RTA Users' Guide." October 2000.

The MDC also is used to send trip manifests to paratransit vehicle operators. Manifests are distributed electronically by 2:00 p.m. the day prior to the trip. Currently, hard copy manifests continue to be distributed along with electronic manifests. In case of a trip addition, change, or deletion after manifests are distributed, this information is communicated to the vehicle operator using the MDC.

The AVL/GPS and GIS mapping function allows dispatchers to view the locations of buses in real-time, with locations refreshed every 60 seconds (the frequency was set at 90 seconds prior to summer 2001). Dispatchers sometimes use the real-time mapping function to identify when buses are off-schedule and take corrective action, in the limited number of cases where such action is necessary. Dispatchers also use the map to estimate a time of arrival, for both fixed-route and paratransit customers who may call in by telephone requesting information. Dispatchers also monitor the locations of buses to identify when a bus is off-route for an unidentified reason. A replay function allows them to retrace buses on particular routes and identify times at specific points.

Figure 5.2 AVL Playback Feature

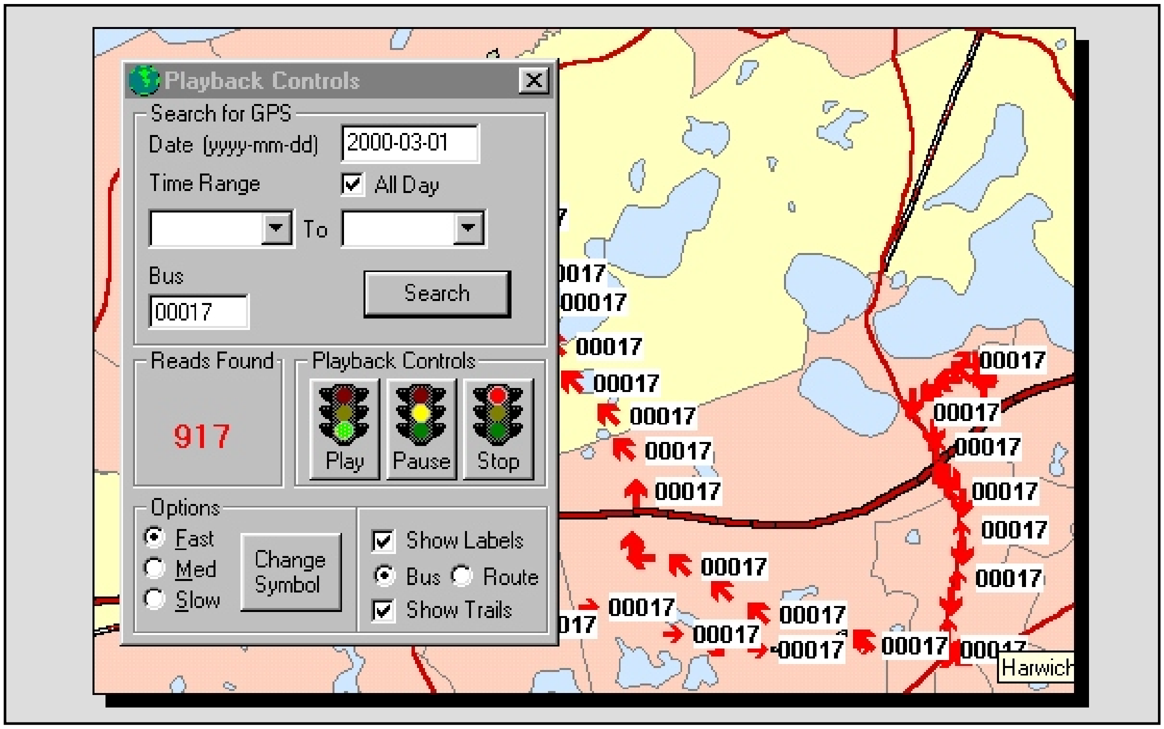
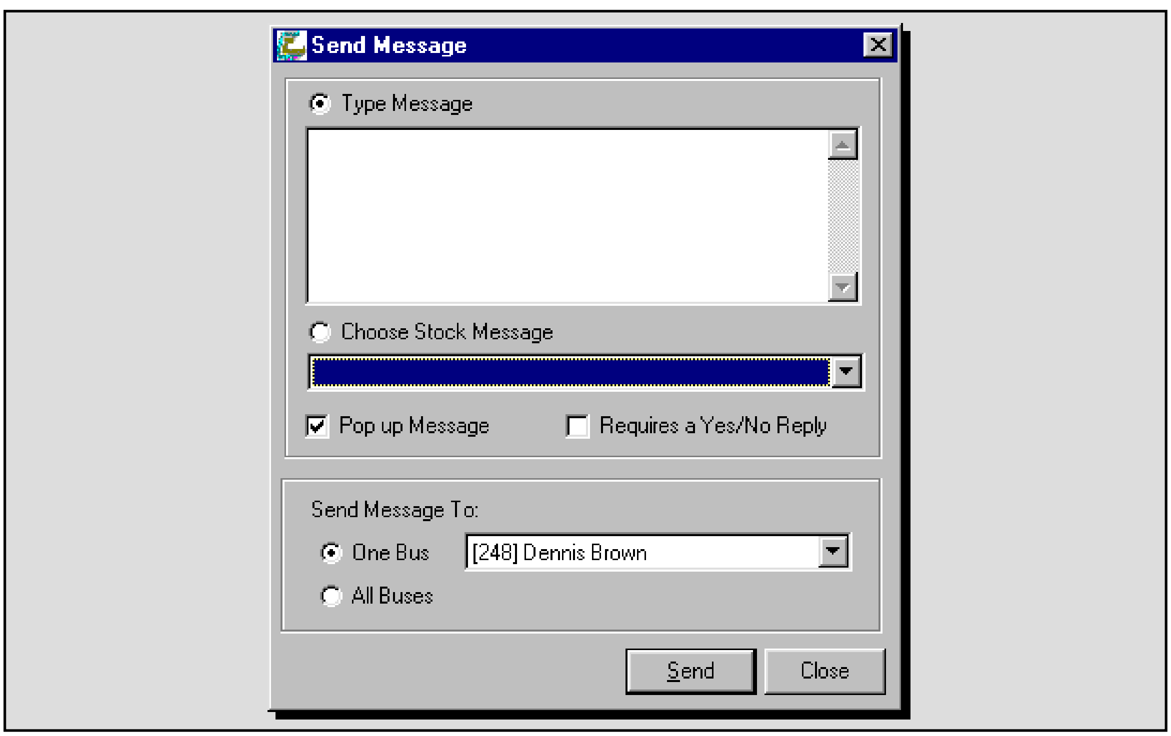


Figure 5.3 Dispatcher Message Window



Fixed-Route Operators

Both fixed-route and paratransit operators interface with the APTS system through the MDC terminal head located on the right side of the driver's seat. This terminal head contains an eight-line LCD display with 40 characters per line, a numeric keypad, and various function buttons. It also contains a slot for inserting magnetic stripe cards. A schematic of the terminal head is shown in Figure 5.4. The GPS unit is located behind the driver's seat.

Operators use the MDC terminal for two primary tasks:

1. Data entry/tracking; and

2. Communication with dispatchers and other operators.

Data Tracking – To activate the MDC, the operator must sign on by entering a four-digit operator identification number and the vehicle's mileage, and then push the start key. During a run, the operator enters the number of passenger boardings and disembarkings at each stop, as well as bicycles and wheelchairs carried. At the end of each run, the operator must signify that the run has ended so that subsequent passengers are assigned to the correct trip. The operator also enters the amount of gasoline when the vehicle is refueled. At the end of the day, operators log out of the system electronically.

In the summer of 2001, as part of Phase 3 of the APTS project, CCRTA initiated a pilot program to explore the use of magnetic stripe card technology. Hotels along the bus routes were identified to distribute passes free of charge to their guests and employees. When boarding or alighting from a bus, the card user was required to give their card to the bus operator, who would insert the card into a slot in the MDC terminal head. If the MDC failed to read the card, the operator was required to enter the card manually via a sequence of keystrokes, including the nine-digit ID number imprinted on the card.

Communication – Operators receive text messages from dispatchers via the MDC; however, they are limited to a list of seven pre-programmed messages as described above or to a yes/no response. These canned messages, which can be reprogrammed, currently include:

1. Ahead of schedule;

2. Behind schedule;

3. Lost item;

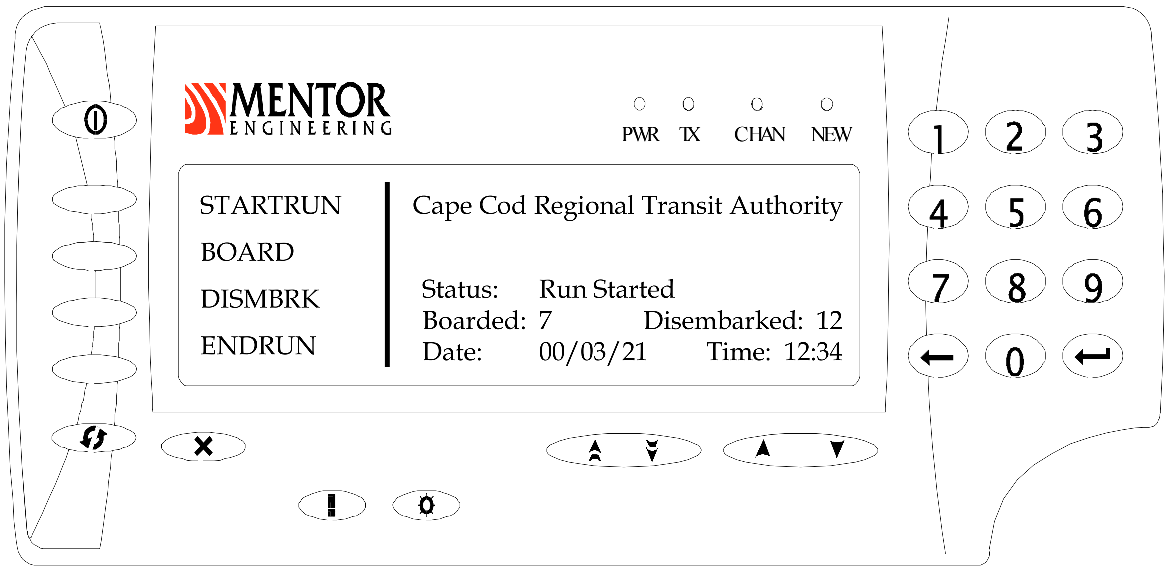
4. Fixed-route passenger waiting for transfer;

5. Medical emergency;

6. Collision; and

7. On break.

Figure 5.4 Schematic of MDC Terminal Head (Main Screen)



In addition to receiving messages from the dispatch center, operators occasionally send and receive messages to other fixed-route operators; the most common use of this feature is to notify an operator that a passenger is waiting for a transfer.

The "silent alarm" is a feature of the MDC intended for use in emergency situations. Silent alarms were first installed on buses in 1998 in conjunction with the installation of Raytheon GPS equipment. At this time, the alarms were usually installed on the floor near the left foot of the bus operator. This location, however, contributed to a high number of false alarms as drivers would accidentally hit the button over the course of the day. The Mentor MDC terminal heads include a red button that activates the silent alarm, replacing the floor button.

Paratransit Operators

Similar to fixed-route operators, paratransit operators interface with the APTS system through the MDC terminal head located on the right side of the driver's seat. While the software for the terminals on paratransit vehicles provides different functions than the software for the terminals on fixed-route vehicles, paratransit operators also use the MDC terminal for the same two primary tasks: data entry/tracking, and communication with dispatchers.

Data Tracking – The day before a run, each operator receives his or her paper manifest for the next day by picking up a copy either at the operations center or at a remote location via fax. The operator also can view an electronic copy of the manifest via the MDC, which is sent by 2:00 the day before the trip. (The operator views this manifest separately from the current day's trips through a "preview" function.) The operators receive the trips in order of scheduled pick-up time. Each operator, however, can use the MDC to rearrange the order of the trips to create the most efficient route within the one-hour pick-up window. Because some trips may on occasion be added or canceled after the paper manifests are created, the electronic manifests may differ from the paper manifests.

At the beginning of a shift, the operator signs in with a four-digit ID and enters the mileage on the vehicle. The operator enters a code as each pick-up is made, or a different code if there is a cancellation or no-show. Similarly, the operator enters a code at each drop-off to record that the drop-off has been made. At the end of his or her shift, the operator signs out and enters the mileage. As each entry is made, the MDC communicates this information back to the control center so that it is stored in the database at the control center, and also so that the dispatchers can view current information such as whether an operator is signed in or whether a trip has been taken.

The MDC data are stored in two tables: a GPS Table, which stores time and location data every 60 to 90 seconds, and an Actions Table, which records operator actions such as logging or passenger boardings. To assess how the MDC is used for data tracking, the "Actions Table" of the MDC database was obtained covering the period of February 2002. Table 5.1 shows the number and percent of actions by type for both fixed-route and paratransit during this period.

Table 5.1 Actions Recorded in MDC Database

	Average Actions per Day			Percent by Type		
Type of Action	**Para-Transit**	**Fixed Route**	**Total**	**Para-Transit**	**Fixed Route**	**Total**
Sign-on/sign-off	51	20	71	56%	4%	12%
Start run/end run	0	81	81	0%	16%	14%
Boarding/alighting	0	356	356	0%	72%	61%
Bus startup/shutdown	21	26	47	23%	5%	8%
Fuel	19	10	29	21%	2%	5%
Wheelchair/bike boarding/alighting	0	4	4	0%	1%	1%
Total	91	497	588	100%	100%	100%
Percent	15%	85%	100%			

The Actions Table includes only data recorded on the vehicle (sign-in, fuel, boardings, etc.). Since the transmission of messages is not archived, it is impossible to assess the number and type of messages transmitted between dispatchers and vehicle operators using the MDC.

Communication – Operators may receive manifests as well as other messages from the dispatch center. The most common use of the MDC to send messages is to notify an operator of a new, changed, or canceled trip and its pick up and drop-off locations. The new trip appears at the bottom of the list, meaning the operator must scroll down to view it, although he or she can subsequently rearrange the order of the trips. A beep notifies the operator that a message has been received, and "priority" messages appear at the top of the screen.

The paratransit operator also can send the same set of canned messages to the dispatch center as the fixed-route operator, but cannot send messages to other operators. MDCs on paratransit vehicles have the same silent alarm feature as do those on fixed-route vehicles.

Management

CCRTA administrative and management staff interface with the APTS system in various ways. They have been involved on an ongoing basis with the development, deployment, and maintenance of the system. They routinely utilize the system's capabilities for two primary purposes:

1. Data tracking and reporting; and

2. Operations oversight.

Data provided by the APTS system are used for reporting and analysis purposes. For example, standard report forms provide monthly ridership and vehicle operating statistics required for the agency's reporting purposes. Maintenance staff rely on vehicle-based reporting of mileage, fuel, and oil use to identify when routine maintenance should be performed and to assess vehicle performance. Management also perform other custom data queries on an as-needed basis; for example, to analyze ridership patterns on a particular route that is being reviewed. An information technology/data analyst staff at CCRTA assists other management staff in performing queries and conducting hardware and software maintenance of the computer network that supports the MDC/AVL system.

In addition, management staff at the operations center utilize the APTS in a similar manner to the dispatchers to oversee operations. For example, they sometimes use it to identify when buses are off-schedule, respond to a customer inquiry or complaint, or to review on-time performance history on a particular route.

5.2 Operational Benefits to CCRTA

Benefits of the APTS system to CCRTA's operations include:

- Operations management;
- Data management;
- New data collection;
- Safety; and
- Job satisfaction.

Operations Management

The communication capabilities and vehicle locating capabilities provided by the AVL/MDC system have improved dispatcher and managerial oversight of vehicles, both on paratransit and fixed-routes. This capability has been used to:

- Improve communications between dispatchers and vehicle operators;
- Facilitate the addition of last-minute paratransit trip requests;
- Help improve on-time performance of fixed-route vehicles; and
- Monitor the performance of operators and of contractors providing service for CCRTA.

Communications

One operational benefit of the MDC system is the ability to send messages electronically via the MDC, as an alternative to voice radio. The ability to send messages electronically has facilitated the reduction in the number of voice radios for dispatchers from one per dispatcher to two for six dispatchers, a measure that was implemented in fall 2000 by a new operations manager. A reduction in voice radio traffic has the benefit of allowing priority voice messages to be received and responded to more quickly. In addition, electronic communication has enabled more reliable transmission of complicated data such as passenger pick-up locations, facilitating last-minute paratransit trip requests.

Interviews suggest that the communication capabilities associated with the MDC are not being fully realized. Operators, in particular, continue to rely heavily on voice radio to contact dispatch. Messaging capabilities for operators are limited, and operators also may not feel confident that their message has been received without confirmation. Dispatchers make somewhat more frequent use of messaging capabilities, in part because they can type messages and in part because of the limited number of voice radios available. The extent to which messages are transmitted by voice radio versus MDC appears to vary depending upon the preference of the individual dispatcher and operator.

Implementation of the MDCs was expected to result in a significant reduction in paratransit scheduling paperwork, by eliminating the need to transmit hard copy manifests. Due to concerns over the reliability of the system, however, both paper schedules and electronic schedules are still currently being distributed. Both dispatchers and operators believe that the MDC system occasionally "drops" trips (perhaps twice a month) and also feel that the operator should have a hard copy in case the MDC fails to function properly (although this is an uncommon occurrence). In addition, operators noted that there are benefits of having both schedule formats. For example, printed schedules allow them to see the entire manifest at one time. The electronic schedules, on the other hand, allow operators to reorder trips within the manifest, making it easier to plan a run.

Last-Minute Trip Scheduling

The combination of knowing where each paratransit bus is, knowing its load status, and being able send text messages to operators has made it easier to accommodate last-minute trip requests. Dispatchers now send additions, changes, and deletions electronically via the MDC, rather than writing notes on paper and calling each operator the day of the trip. Dispatchers estimated that three to five trips a day are typically added after the 11:00 deadline, and that roughly five to 10 trips a day are canceled after this deadline.

However, dispatchers still discourage customers from scheduling trips after the official 11:00 a.m. previous-day deadline. Dispatchers also claim that the APTS system has not led to an increase in the number of last-minute trips accommodated. According to one dispatcher, "The real issue is, can the driver handle the additional trip, not can we get the message to the driver."

On-Time Performance (Fixed-Route)

Of the dispatchers, operators, and management staff interviewed for this evaluation, none felt that the APTS system has had a significant effect on on-time performance. Management, however, noted that the APTS may have had incremental benefits by assisting in maintaining headways, especially under congested traffic conditions during the summer. Management also noted two areas in which APTS is being used to support improved on-time performance in the future, through routine tracking of on-time performance and through data collection to facilitate schedule and route adjustments.

Data regarding on-time performance were not routinely collected or maintained prior to implementation of the APTS. A good "before-and-after" comparison of on-time performance is therefore not possible. However, GPS data have been collected for the past three years on summer trolley routes (1999-2001) and could potentially be used to assess if changes in operational procedures over this time period have led to improvements in on-time performance.

Maintaining Headways

The AVL has occasionally been used by dispatchers and supervisors to assist in keeping buses on set headways.[1] CCRTA has had problems with fixed-route services bunching, primarily on the summer trolley routes, due to traffic congestion. During the first year the AVL was deployed on the summer trolley routes (1998), CCRTA used the AVL to track the trolley vehicles. In doing so, they found that the vehicles were often off-schedule so that vehicles were improperly spaced. The CCRTA response was to control the departures of the trolleys so that they were not leaving one after the other. They divided the fixed-routes among the dispatchers, each of whom was in constant communication with one or two operators. The operators would message the dispatchers with information about how late they were, and the dispatchers would make decisions on whether to layover longer or start the run.

The AVL with GIS base station makes it easier for dispatchers or supervisors in the operations center to function as run starters. Without the benefit of this equipment, dispatchers would have to use the voice radio system to contact operators to report their positions and to check that position in relation to other operators. Since AVL data or other on-time performance data were not collected prior to 1999, however, there is no way of quantifying the benefits of changes in operating procedures that occurred in 1998 or 1999 to make use of the AVL in controlling operations.

CCRTA has recently abandoned time schedules on the summer trolleys altogether, and simply advertised headways to the customers. This practice was started on a trial basis in Provincetown in 2000 and adopted on the Barnstable-Hyannis and Woods Hole routes in 2001. Trying to maintain a schedule was too difficult given the unpredictable and time-varying congestion which would occur, for example, in conjunction with the rush to the beach in the morning. However, despite the change in schedule practices, management did not feel that there had been a significant shift in operational practices for the summer 2001 trolley routes compared to summer 2000. They noted that dispatchers sometimes monitored routes but did not do a lot of run starting. Operators typically tried to start runs according to a "scheduled" time. Buses were held over to the next run in only a few cases.

The ability to maintain scheduled headways under congested conditions also depends upon the number of buses available for the route. CCRTA noted that in summer 2001 for the Hyannis route, three buses were normally required but up to five were sometimes made available if necessary. On the Woods Hole Trolley, however, they rarely had the resources to make more than the three required vehicles available.

Since GPS data have been collected and archived on summer trolley routes since summer 1999, an effort was made to determine whether a good "before and after" experimental

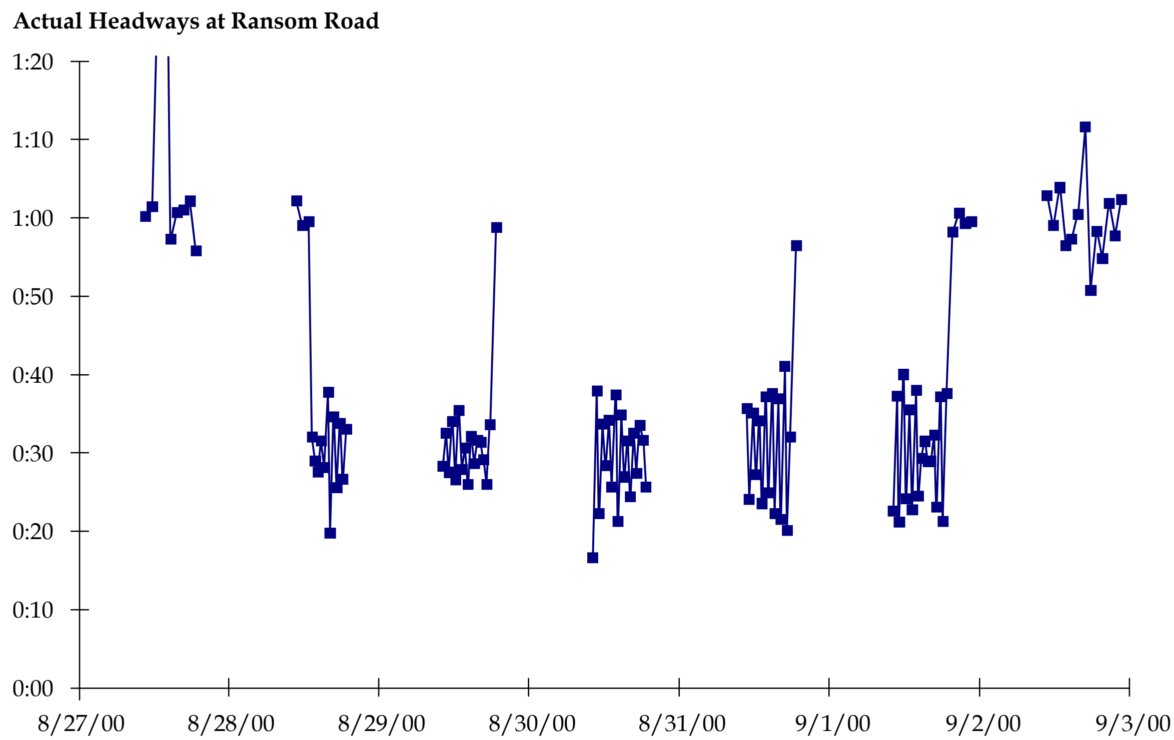
---

[1] Maintaining fixed headways, by itself, does not necessarily result in improved schedule adherence. However, if it is impossible to maintain schedule adherence because of traffic congestion, maintaining consistent headways may still result in reduced average waiting times, especially if customers do not know when to expect the bus.

situation existed in which variability in headways could be compared on the same route, between two subsequent years in which a fixed-headway system was implemented in the second year. The only potential situation for this was to compare the Woods Hole Trolley between summer 2000 and summer 2001. One week of GPS data from the last week of August was obtained and evaluated for both summers.

An example of the data from summer 2000 is shown in Figure 5.5. Figure 5.5 illustrates one way in which the AVL data could be used by operations management to review operations and make adjustments where possible to reduce variability in arrival times. In this figure, the weekday points (8/28 – 9/01) should cluster as close to the 30-minute mark as possible; variation around this mark shows that one of the two buses is running ahead (or behind) relative to the other.

Figure 5.5 Example of Use of AVL Data to Assess Headway Variance



Three problems were encountered in this analysis. First, there were a number of runs missing from the 2001 GPS data (usually, at least one per hour) which made it impossible to evaluate headways. The data that did exist did not show an obvious decrease in variability. Second, a decrease in headways from 30 to 20 minutes was implemented on this route in 2001, a change which might also have affected the variability of headways. Third, as noted, management did not feel that there had been a significant shift in operational practices for the summer 2001 trolley routes, including Woods Hole, compared to summer 2000. Therefore, there was no basis for expecting a significant reduction in the variability of headways.

It is not clear that the potential benefits of the AVL for maintaining fixed headways on fixed-route service have been achieved, at least in a measurable sense. In the future, staff will continue to become more comfortable with the AVL system and better able to utilize its full range of capabilities.

Other Potential Benefits to Fixed-Route On-Time Performance

In addition to allowing real-time adjustments to operations, the ability provided by the AVL to track on-time performance could potentially help CCRTA improve its performance in two other ways. First, management noted that operators might be more careful about sticking to their schedule if they know they are being monitored. Starting in January 2002, CCRTA began a systematic program to track on-time performance on all routes, first through manual review of data by dispatchers, and then by developing an automated query to track on-time performance. Benefits resulting from this monitoring could potentially show up in future assessments of the impacts of the APTS system.

Second, the AVL can be used to review on-time performance history on a particular route and make longer-term adjustments to schedules, which can help to improve on-time performance or reduce allotted run time. This benefit is discussed under "new data collection."

Paratransit Pick-Up Window

None of the staff interviewed felt that the AVL system has had a benefit for paratransit operators in terms of reducing the difference between actual versus scheduled pick-up times. Customers are provided with a one-hour window in which they can expect to be picked up, and this window has not been adjusted. Paratransit operators are familiar with common routes and the road network on the Cape, and are generally able to create an efficient routing pattern themselves. The current APTS system was not designed to enhance their ability to create more efficient routes or maintain a set pick-up schedule.

Monitoring Operator and Contractor Performance

The AVL system has been be useful for identifying improper operator behavior. Due to the size of the service area, administrative staff noted that vehicles can sometimes "disappear," and it is helpful to know where the vehicles are at all times. While such situations are uncommon, occasional misuse of vehicles by operators has been identified using the AVL and appropriate disciplinary action taken. Management stated that such situations have been identified approximately once a month. As operators become familiar with the APTS system and realize that their actions can be tracked, it is possible that they will be less likely to make obvious transgressions such as going off-route or missing a run. However, this is a relatively rare problem and most operators do not intentionally engage in such practices.

Through the capabilities of the equipment, CCRTA staff also are able to track and compare the performance of their privately contracted services. They monitored the performance of three contractors employed in summer 2000 using two methods: 1) using the AVL-recorded bus positions to track actual routes driven and review using the "replay" function on the base station software; and 2) comparing billed versus actual hours in service as recorded by the MDCs. While two contractors had "almost perfect records," problems were found with the third, including those noted below:

1. **Routes –** Some anomalies were noted in routes driven versus scheduled, including a routinely missed stop. One vehicle was occasionally used as a courier to Plymouth, outside the service area.

2. **Hours –** Evidence was found that billed hours did not match actual hours, and also that some drivers were not logging in or out. After comparing APTS data on actual with reported vehicle-miles of service and on the routing of vehicles, CCRTA terminated the service provider's contract. In this particular situation, the ability to monitor contractor performance potentially represented a financial benefit to the Authority as well as improving service for its customers.

Data Management

The MDCs have supported electronic data collection of fixed-route passenger boardings and alightings, paratransit trips taken, driver log-in and log-out, vehicle mileage, and vehicle gas and oil consumption. In summer and fall 2000, a transition period was implemented in which fixed-route passenger counts and vehicle operating data were kept both on paper and with the MDCs. As of December 2000, paper tracking of these data was eliminated unless the MDC was not working. Paratransit data have been kept electronically since the MDCs were introduced on all paratransit buses between May 2000 and January 2001.

The accuracy and reliability of the electronic data entry system appears to be good when used correctly. The CATS operations manager at the time reported that in summer 2000, they ran both paper and electronic systems on fixed-routes with the AVL/MDC equipment and found only a four to five percent variance between counts. However, some anomalies were reported in electronic data collection of passenger counts during summer 2001. For example, some routes showed ridership of hundreds of people. In addition, an estimated 25 to 40 percent of fixed-route trips were not entered electronically, but instead were tracked using paper logs and were entered manually at the CCRTA operations center.

A variety of potential explanations have been provided for the anomalies in data entry observed and the widespread use of paper data tracking observed in summer 2001. These include:

- Non-functional MDC due to dead spaces (especially in Woods Hole and Harwich), software glitches, or system down;
- Magnetic swipe cards not working or not being used correctly;
- Part-time or new operators unfamiliar with the use of the MDC;
- Difficulty in seeing/using the MDC keypad in the dark; and
- Inability to log in if not logged out properly.

Operations management notes that due to the large number of temporary staff hired for the summer as well as barriers in training on the use of the MDC system (such as language and computer unfamiliarity), that not all operators may have been fully familiar with the system, especially near the beginning of the summer. More aggressive training and oversight measures are planned for the summer of 2002 to avoid some of the data problems experienced during the summer of 2001.

Electronic data entry has begun to reduce the administrative burden for data entry and quality control, and has the potential to reduce it more in the future. Prior to the electronic system, administrative personnel working in the evening spent an estimated 20 to 25 person-hours per week compiling manually recorded ridership data into a spreadsheet and running quality assurance/quality control (QA/QC) checks. That need has been reduced to an estimated four to five person-hours per week with the electronic data collection, as the only need ultimately will be to provide a QA/QC check on the data that has been electronically entered into the database.

Also, prior to implementation of the AVL system, weekend dispatchers were responsible for manually entering vehicle operating data, including mileage, gas, and oil consumption from paper log sheets. Management estimates that this task required about 20 person-hours a week. Since the information is now entered directly by the vehicle operators into the MDC, manual entry is no longer necessary. As a result of the electronic entry of passenger and vehicle data, CCRTA was able to eliminate a full-time data entry position by attrition in fall 2001.

New Data Collection

In addition to reducing the administrative burden associated with data collection, the AVL/MDC system is collecting new data to support operational planning. These data can be characterized as the space/time coordinates of vehicles and of passenger boardings and alightings. The AVL database, which can be read in real-time as well as archived for future use, includes a "GPS Table" with the latitude and longitude coordinates of each bus sampled every 60 to 90 seconds during operation. This table also includes the vehicle's direction and calculated speed. An "Actions Table" includes time, latitude/longitude coordinates, operator and bus identifiers, fuel use, number of boardings and alightings at each stop for fixed-route vehicles, and magnetic stripe card transactions. Each record in the Actions Table is identified by type of action, including:

- Sign-On;
- Start Run;
- Boarding;
- Alighting;
- End Run;
- Sign-Off;
- Bus Shutdown;

- Bus Startup;
- Skipped Run;
- Fuel;
- Wheelchair Boarding;
- Wheelchair Alighting;
- Bike Boarding; and
- Bike Alighting.

The AVL data are used to identify the number of passengers boarding and alighting by route, time, and location, and, with additional query development, to compare actual with scheduled arrival times of buses. The system, however, does not currently record latitude and longitude for paratransit passenger boardings and alightings.

Administrative staff felt that the AVL/MDC "creates powerful capabilities for improving service." They noted three specific examples in which data have already been used to assist in making changes to routes:

1. Shortening run time on the H2O Line (between Hyannis and Orleans);
2. Routing and timing of the former parking lot shuttle in Hyannis; and
3. Restructuring fixed-routes in the Hyannis area.

Shortening Run Time on the H2O Line

Operators and passengers were complaining that too much time was allotted to the H2O route – specifically, some buses were arriving early in Chatham, and some were either leaving late or driving slowly to avoid this. Operations staff used the AVL replay to verify that there was too much time allotted and confirm what operators and passengers had been telling them anecdotally (which they felt are sometimes are subject to exaggeration). Schedules were subsequently adjusted.

A review of H2O schedules comparing 1999 and 2000 suggests that the run time was shortened by one to three minutes, so the amount of the adjustment was relatively small (1.1 to 3.5 percent of the total run time).

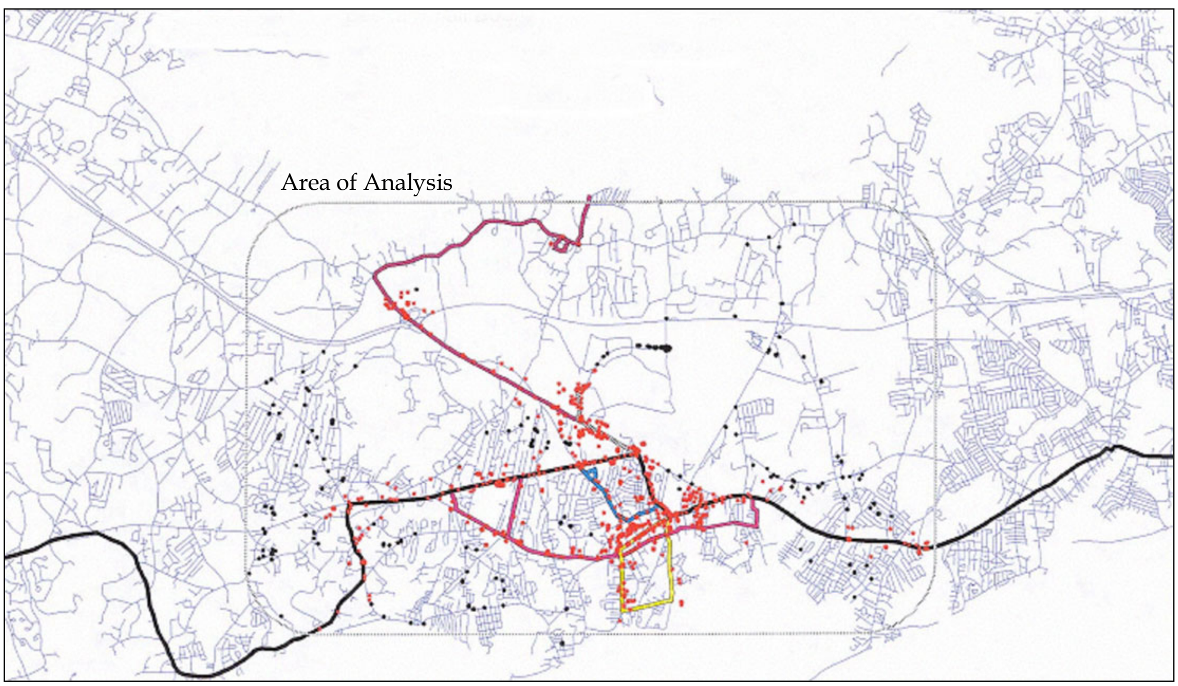
Hyannis Park-and-Ride Shuttle Routing and Timing

The Hyannis park-and-ride shuttle, which operated during summer 1999 and 2000, was a remote shuttle for the Nantucket ferry. The prescribed route could be very congested and as there were no interim stops, it was not necessary to use this route. Dispatchers noticed with the AVL that operators were sometimes deviating from the route and taking back-roads. The AVL was used to confirm operators' anecdotes of congestion along the prescribed route. As a result, they went to specified headways instead of a time schedule and also allowed the route to vary at the operator's discretion instead of being fixed.

Hyannis Area Route Restructuring

A team of staff and students at the Moakley Center at Bridgewater State College plotted fixed-route origins and destinations from the AVL data as well as a set of paratransit trips from September and October 2000 that were manually geocoded. Origins and destinations were plotted over digital orthographic photos and street maps (Figure 5.6). They found many origins and destinations in the vicinity of West Main Street in Hyannis, which made it a good candidate for fixed-route service. They "used the ridership data to connect the dots," revising the Villager route and adding a new year-round Bearses Way Shuttle (Figure 5.7). The revised year-round routes, in conjunction with a new seasonal Hyannis Beaches Trolley, also replaced the two former Hyannis Area Trolley routes that operated during the summer.[2] The benefits of this route restructuring are investigated under "Ridership and Farebox Revenue," below.

Figure 5.6 Geocoded Boarding Data

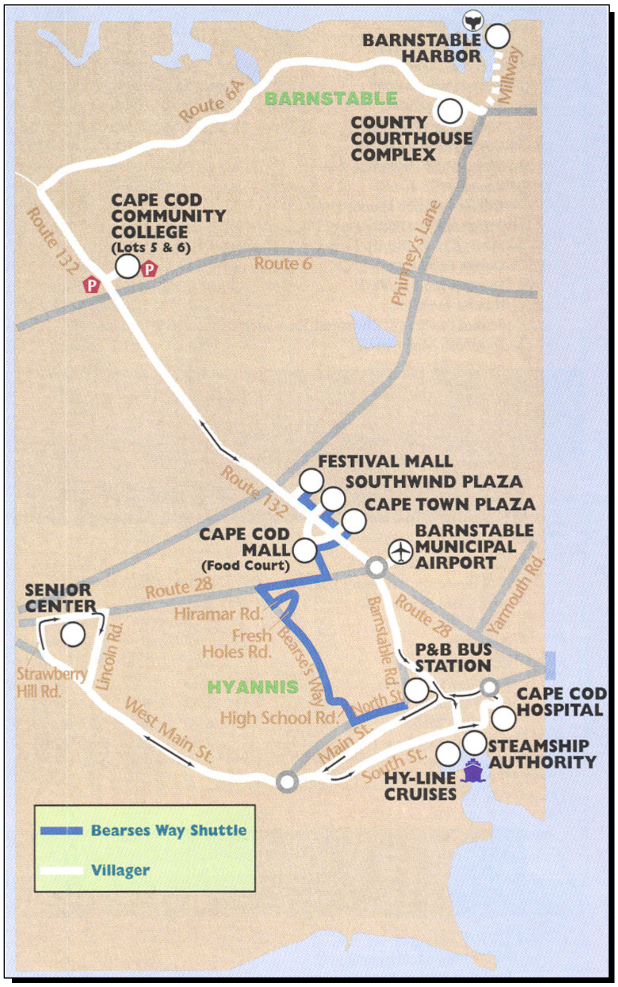


Source: Geographics Laboratory, Bridgewater, MA.

Note: Dots indicate locations of paratransit boardings between September 10 and October 31, 2000. Solid lines show fixed-route service at the time of the analysis. Seventy-two percent of boardings are within one quarter mile of a fixed route.

[2] The route restructuring is documented in a CCRTA report: *Hyannis Villager 2001 Summer Service.*

Figure 5.7 Restructured Villager Routes in Hyannis



Source: Cape Cod Regional Transit Authority.

A significant limitation of the current Mentor/TriStar system is that paratransit trip origins and destinations are not automatically geocoded – i.e., a latitude and longitude are not automatically recorded unless the operator hits a function key when boarding or alighting, which is not done routinely. Geocoding of paratransit trips was performed manually by students at Bridgewater State College using address-matching technology. This was labor-intensive, but the results give some indication of the potential usefulness of automatically geocoded data on paratransit trips. To geocode paratransit trips, either the operator would be required to hit a key upon boarding or alighting and the MDC programmed to record latitude/longitude at this time, or the addresses of paratransit clients and destinations must be geocoded.

The "tourist pass" program pilot-tested in summer 2001 has provided additional data that may be useful to CCRTA in future marketing and promotional campaigns; specifically, on the ZIP codes of residence, as well as origins and destinations, of both visitors and hotel employees using the tourist pass. The pilot program undertaken in summer 2001 also has provided information on where there are high concentrations of visitors who are potential transit users, and therefore on where to focus marketing and service efforts in the future.

Safety

Management, dispatchers, and operators all noted the potential safety benefits associated with the silent alarm and AVL. However, there have only been two instances in which the silent alarm has been used in an actual emergency. One of these instances occurred when a passenger with a knife threatened an operator and told him not to use the radio. The operator pressed the silent alarm which was located on the floor of his vehicle,[3] and dispatch-notified police who responded to the incident. The other incident occurred when an operator needed assistance removing a drunk and disorderly passenger from his vehicle.

The AVL is also useful for tracking the vehicle when an incident occurs, even if the operator does not use the silent alarm and instead calls in the incident on the radio. The primary examples include unruly passengers or medical emergencies. In each case, the operator may be involved with on-scene circumstances and may not be able to update his or her position to the dispatchers or police. Because of the AVL, the dispatchers can track the vehicle in real-time (it may be moving) and assist police in locating it. The AVL has been used for this function "once or twice a summer."

Even if they had not used it in a real-world emergency, the operators interviewed liked the added security of the silent alarm and its AVL tracking feature. However, they voiced concerns regarding the position of the alarm on the MDC terminal head, citing its location as being too obvious to use in a real emergency situation. The operators also stated that in most emergency situations they would radio for help, because they would get immediate confirmation that they had been heard and could communicate the nature of their problem. They would use the silent alarm only in a situation where radio use was dangerous or impossible.

Job Satisfaction

Dispatchers and operators interviewed were asked to rate from an overall standpoint, whether the APTS equipment had made their jobs easier or more difficult.

Each of the dispatchers interviewed felt that the use of APTS equipment has made their job "much easier." Facilitating communication with operators was probably the most significant benefit cited by dispatchers. Assisting with last-minute trip requests and changes,

---

[3] This incident occurred prior to the installation of the MDC terminal heads with emergency button.

responding to customer requests for information, and identifying improper operator behavior were cited as smaller but still significant benefits. Dispatchers also appreciated the opportunity to learn and utilize "advanced technology" and improve their computer skills.

Two of the three fixed-route operators interviewed felt that the APTS equipment had made their jobs "a little easier" by making it easier to track vehicle and passenger data. The third operator stated the equipment did not make his job any easier – "only more pleasant." All three of the paratransit operators interviewed felt that the APTS equipment had made their jobs "a little easier," primarily because of the electronic data entry and communication functions, although one also felt that it made his job "a little more difficult" when the equipment was not working.

Some transit properties implementing AVL have reported actual or potential concerns about the acceptance of operators of a system that is constantly tracking their position.[4] In CCRTA's case, however, this does not seem to be a concern. None of the six operators interviewed expressed concern that CCRTA management could monitor their actions using the AVL. All felt that if they were doing their job properly, they had nothing to hide or be concerned about. In general, CCRTA management felt that operators have come to accept the AVL tracking system and its use. For example, the AVL has been used to resolve a number of customer complaints about missing or speeding buses. Most of these complaints have been resolved in the operator's favor. Operators, therefore, see that the AVL has been used to their benefit, and that it has been used as grounds to reprimand operators only in rare cases of negligent or inappropriate behavior.

■ 5.3 Costs to CCRTA

Costs of the APTS system to CCRTA include:

- Capital costs;
- Maintenance costs; and
- Staff time (initial and ongoing).

---

[4] c.f. Weatherford, Matt. *Assessment of the Denver Regional Transportation District's Automatic Vehicle Location System*. Prepared for Federal Transit Administration and Volpe National Transportation Systems Center, August 2000.

Capital Costs

Capital costs for the APTS system include the following categories:

- **Research and Development Costs –** Including design, development, and installation of system hardware and software by contractors;
- **Capital Infrastructure –** Including computer hardware and software, communications equipment, and MDC and AVL units on each vehicle;
- **Maintenance –** First-year maintenance costs for LAN administration and optimization and the Mentor system. These are paid for by grant funds but to some extent could be considered operations and maintenance rather than capital costs;
- **Project Management –** Including technical direction, grant writing, vendor management, and GIS data analysis by the project manager and staff at Bridgewater State College; and,
- **Other Costs –** Including travel.

These costs, as estimated by CCRTA administrative staff, are shown in Table 5.2. Capital costs for the Cape Cod APTS project, Phases 1 and 2 have totaled roughly $1.23 million. However, this estimate includes $150,000 in CCRTA staff time as noted in Section 3.5. Capital costs not including CCRTA staff time are estimated at $1.08 million.

It is of interest to ask to what extent these costs are generalizable to other transit agencies that may wish to undertake their own APTS project. The specific costs for a project of this type largely depend on the context of the project, the state of technology when it is undertaken, and the resources available. A number of relevant characteristics can be noted with respect to the costs incurred for Cape Cod's APTS system:

- The Raytheon AVL/GPS system, a pilot system installed on 20 vehicles in 1998, was later discarded in favor of the more flexible Mentor system which included an integrated AVL/GPS, MDC, and electronic fare payment capability, as well as open-systems architecture. Thus, $117,953 of the capital infrastructure costs represent equipment that was not ultimately used.
- This project was an early demonstration project – one of the first examples of an application of ITS to rural transit. Therefore, there was much to learn on the part of the transit agency, project management, consultants, and vendors. CCRTA noted that its original contractor, in particular, spent a considerable amount of money on research and development which might not be necessary once the contractor had more experience with the technology. Specifically, only $117,953 of $350,000 in contracts for this vendor was spent on hardware.

Table 5.2 APTS Phase 1 and 2 Funded Capital Costs

	Total	Percent
Research and Development		
Design	$98,075	8.0%
Installation	$98,394	8.0%
ATP/web site development	$11,625	0.9%
Bridgewater State College overhead	$14,250	1.2%
Subtotal	**$222,344**	**18.0%**
Capital Infrastructure		
Radio towers upgrade	$69,015	5.6%
LAN	$117,920	9.6%
Raytheon AVL system	$117,953	9.6%
Mentor AVL/MDC/EFP system	$386,041	31.3%
Software upgrades/evaluation	$61,606	5.0%
Subtotal	**$752,535**	**61.0%**
Maintenance[1]		
LAN admin/optimization	$34,838	2.8%
Mentor system	$34,983	2.8%
Subtotal	**$69,821**	**5.7%**
Project Management		
Technical director/grant writer/vendor management	$95,040	7.7%
GIS data analysis	$64,921	5.3%
Subtotal	**$159,961**	**13.0%**
Other		
Travel	$28,520	2.3%
Total	**$1,233,181**	**100.0%**
Total less CCRTA staff time	**$1,083,181**	

[1] These are one-time, first-year maintenance costs covered by the grant funds received for the project. Ongoing annual maintenance costs are not included in this table.

- The Mentor units cost between $3,000 and $3,250 apiece at the time of purchase, for a purchase of 100 units. The units and software ultimately selected also represented "alpha-test" versions that had not previously been implemented to meet the same requirements as for the CCRTA system (e.g., both fixed-route and paratransit functionality). It is possible that as the technology becomes proven, per-unit costs will decrease.
- The existing communications infrastructure, needs, and most logical solutions will vary widely from area to area. CCRTA chose to take a relatively capital-intensive approach to communications, involving a dedicated radio system, which allows them to transmit data at zero marginal cost. In doing so, CCRTA was able to take advantage

of a radio frequency made available at no cost by a local fire department to reduce their capital investment. Other communications options, such as CDPD, require negligible capital investment but have a high marginal cost per unit of data transmitted. In this case, CCRTA reports that a relatively small up-front investment of $15,000 to fund a study of communications options, funded through Phase 1 grants, was extremely helpful in clarifying options and selecting the best option.

- The existing computer hardware and software and upgrade requirements will also vary from agency to agency. At the time of the project, upgrading to a LAN with state-of-the-art computers was a necessity for implementing the APTS. As existing network infrastructure and computer systems continue to improve at many agencies, the incremental costs of system upgrades to support APTS could be less at other agencies.

- The project manager for this project, a research staff at a local university, had over 25 years of experience in transit operations and technology. Project management also had close working relationships with CCRTA administration and operations management. CCRTA reports that this proved to be a major advantage in terms of designing the system and overseeing its implementation to obtain a system that met the agency's needs. It is likely that some transit agencies, especially larger ones, will have a considerable amount of technical knowledge available internally. Other agencies, however, will need to draw on expertise outside the agency and possibly even outside the area, which could increase costs.

- Scalability is an important consideration. Some costs, such as the systems design, network, and communications infrastructure, are relatively fixed (although capacity upgrades may be required depending upon the number of vehicles served). Only the cost of the units on the vehicles bears a one-to-one relationship with the number of vehicles. As the number of vehicles operated by the agency increases, the system cost per vehicle is likely to decrease.

Given all of these factors, it is impossible to say to what extent the Cape Cod APTS costs may reflect future APTS project costs at other agencies. The Cape Cod project was placed at a cost disadvantage by being an early demonstration project. As transit agency staff, consultants, and vendors increase their experience with APTS systems, costs are likely to decline. On the other hand, CCRTA benefited from project management and staff with considerable capabilities to conceive, design, and implement an APTS system. Not all agencies are likely to have access to such a strong local knowledge base.

To place the capital costs of the system in perspective, it is useful to compare the costs of the AVL and MDC units to the cost of a bus. An MDC unit costs about $3,000 to $3,250. This represents about five percent of the total cost of the average vehicle in CCRTA's fleet, most of which are minibuses costing about $55,000. It represents about two to three percent of the $110,000 to $140,000 cost of a 30-foot bus such as the ones used on the year-round fixed-routes and Provincetown Shuttle. CCRTA has included the cost of MDC purchase in recent FTA Section 5307, 5309, 5310, and 5311 capital grants for bus purchase.

The cost of the entire capital infrastructure – including communications system, local area network, Mentor AVL/MDC units, and software upgrades – also can be compared on a per-bus basis. The total cost for this capital infrastructure was $634,582, which represents $6,346 per unit for 100 units. This figure represents roughly 10 percent of the average cost of a vehicle in CCRTA's fleet ($61,000).

Operating and Maintenance Costs

The estimated annual operating and maintenance costs associated with the APTS Phase 1 and 2 system are shown in Table 5.3. Mentor/Tristar offers an annual contract with their units that includes maintenance, warranty, and software upgrades. The cost for FY 2002 of this maintenance contract to CCRTA is $32,000 annually for 100 units, or $320 per unit. Equipment replacement and repair is estimated at 10 percent of initial investment costs per year. Other costs include the dedicated lease lines for data transmission between the three towers and the operations center, and LAN maintenance, including system upgrades. While the amount of staffing remains the same, the APTS requires an information technology/data analyst position (discussed under "staff time") to replace the data entry position which has been eliminated. Since the analyst is a higher-value position, the additional cost is estimated at $20,000.

Table 5.3 Estimated APTS Annual Operating and Maintenance Costs

Item	Cost
Extended warranty/maintenance contract	$ 32,000
Equipment replacement/repair (estimated at 10 percent)	38,604
Data transmission (lease lines)	8,580
LAN maintenance	8,000
Information technology/data analyst[5]	20,000
Total	**$107,184**

As with capital costs, it is helpful to place maintenance costs in the context of CCRTA's annual operating budget. This budget for SFY 1998 through 2002 is shown in Table 2.7. As of SFY 2001, CCRTA's total operating budget was about $5.0 million. Thus, annual operations and maintenance expenses represent 2.0 percent of the agency's current annual operating budget.

[5] Estimated as the difference in salary and benefits between the information technology/data analyst position (newly created) and previous data entry position (eliminated).

Staff Time

CCRTA noted a significant input of staff time both for setting up the system as well as for its ongoing maintenance. As described in Section 3.5, CCRTA estimates that the total value of administrative and operations staff time that went into Phases 1 and 2 is on the order of $300,000, although this is a very rough estimate since staff time has not been tracked by task. CCRTA used $150,000 in paratransit operating funds to partially cover the staff time required for the project.

CCRTA staff also were asked to estimate how much time they have spent on the APTS project since its inception. The CCRTA Assistant Administrator estimates that management of procurement and deployment has taken an estimated 25 percent of his time from the beginning of 1998 through the end of 2001. Deployment and implementation has taken perhaps 25 percent of both the CATS manager and assistant managers' time since the beginning of deployment in mid-1998, sometimes requiring up to 40 percent of the assistant manager's time. The maintenance supervisor estimated that it took about 25 percent of his time for eight to nine months to install the MDC/AVL equipment and get it working.

Overall for the Authority, since full deployment was completed in summer 2001, the APTS project continues to require about 25 to 30 percent of one management staff person's time. However, only minimal maintenance staff time (perhaps a couple of hours a month) is required for ongoing maintenance support of the hardware, now that installation has been completed and the bugs have been worked out of the system.

CCRTA realized the need for a full-time information technology/data analyst staff person to support both the hardware and software associated with the system, and to take advantage of its data-related capabilities. They note that there are hardware and software issues that constantly need attention, and that having a person present who is skilled with the technology helps to address problems quickly and reduces headaches for the operations management staff. They also note that proficiency in Special Query Language (SQL) is necessary to be able to write queries to extract data from the MDC database. Both of these capabilities were provided by an intern from Bridgewater State College in summer 2001, who temporarily became an employee in fall 2001. When this person left, CCRTA hired a replacement in December 2001.

As previously noted, the APTS system benefited CCRTA by eliminating the need for approximately one full-time administrative position for data entry and quality control. Responsibilities eliminated include entering fixed-route transit boardings from tally sheets, vehicle data (mileage, gas, and oil) from log sheets, and records of paratransit trips taken. Because of the reduced data entry needs, one staff position was eliminated by attrition in fall 2001.

Minor time savings appear to have accrued to dispatchers and operators; operators because they do not need to call the operations center to sign in or out or complete paperwork at the end of the day, and dispatchers by using electronic messaging instead of voice radio. However, because these savings accrue in small, dispersed increments, there is no easy way to assess or measure their benefits. Neither dispatchers, operators, or management could identify specific time savings due to the APTS or pin down what they thought staff might be doing with this "extra" time.

Overall Cost Implications

It is helpful to examine how much the APTS system adds to the total cost of providing transit service. This places the costs of the APTS system in perspective and can help in comparing costs with benefits, especially given that most of the benefits to date cannot be expressed directly in monetary terms.

This is not a straightforward task. Capital expenditures are "lumpy" – that is, they vary considerably from year to year depending upon needs and the availability of grants to support specific investments. Also, the useful life of the APTS components and system is not yet known. However, sensitivity analysis can test a range of probable values for these parameters.

The following assumptions are made in this analysis to estimate CCRTA's *total* annualized capital and operating costs (Table 5.4):

- CCRTA's annual operating budget is $5 million (the SFY 2001 level).
- The total annualized value of CCRTA's rolling stock is $640,000. This is based on 84 total vehicles,[6] an average new purchase value per vehicle of $61,300, and an average life span of a vehicle of eight years.
- The total annualized value of CCRTA's other capital needs is $300,000. This is a rough estimate. It is based on the ratio of rolling stock expenditures to "facilities and other" expenditures from the 1996 through 2000 period, as obtained from the National Transit Database. For this period, total capital expenditures on rolling stock ($3.4 million) were just over twice that of total capital expenditures on facilities and other equipment ($1.6 million). Capital expenditures can vary significantly over the course of time, however. For example, the 1996 through 2000 period includes grants related to the Hyannis Intermodal Terminal.

To annualize the total capital cost of the APTS system, a range of values from 10 to 20 years was used for the assumed life span of the system. The total capital cost was calculated as inclusive of CCRTA staff time ($1.38 million). The annualized capital cost was then added to the annual operating cost of the system. The resulting annualized total cost ranges from about $180,000 to $250,000, or three to four percent of CCRTA's total annualized capital and operating expenditures. These results are shown in Table 5.5.

---

[6] Summer trolleys are leased and are included in operating expenditures.

Table 5.4 Estimated CCRTA Annualized Capital and Operating Costs

Item	Amount
Annual Operating Budget	$5,000,000
Annualized Cap. Value – Rolling Stock	640,000
Annualized Cap. Value – Other	300,000
Total Annualized Expenditure	**$5,940,000**

Table 5.5 Total Annualized Cost of APTS

	Assumed Life Span of System (years)			
APTS Phase 1 and 2	**Amount**	**10**	**15**	**20**
Total Capital Cost	$1,380,000	$138,000	$92,000	$69,000
Annual Operating and Maintenance Cost		110,000	110,000	110,000
Total Annualized Cost		248,000	202,000	179,000
Percent of CCRTA Total Annualized Expenditures		4.2%	3.4%	3.0%

■ 5.4 Systemwide Performance Measures

Ridership and Farebox Revenue

Ridership increases on fixed-route service can benefit CCRTA by increasing farebox revenue. Ridership increases also can provide a larger benefit to society by reducing vehicle traffic and related emissions and environmental impacts, if people shift modes from private vehicle to transit. Finally, ridership increases can indicate that more people are benefiting from the service provided by CCRTA.

Overall Ridership Trends

Ridership data by month and route (for fixed-route services) and town (for paratransit services) were available from 1996 through October 2001. Summaries of ridership by year are shown in Table 2.3 and 2.4 as well as Figure 2.7. These data show that paratransit ridership steadily declined over this period, while year-round bus ridership increased significantly in 2001 in conjunction with expanded service frequency. Summer shuttle ridership has also increased rapidly, especially in the 1999 through 2001 period.

No immediate conclusions can be drawn to relate ridership changes to APTS implementation. It should be noted that many other factors – both observable and unobservable – can influence ridership both at a route level and a system level. Some potentially significant and measurable factors include: changes in frequency of service on specific routes; route restructuring; and changes in overall levels of visitation to the Cape. A factor that is more difficult to quantify is the level of marketing, which may affect peoples' awareness of transit services on the Cape. Changes in socioeconomic conditions, such as unemployment levels and population without a vehicle available, also could affect ridership from year to year.

Beyond looking at overall ridership trends, it is helpful to consider specific APTS-related mechanisms that could potentially lead to increased ridership, and whether the effects of these mechanisms can be assessed individually. These mechanisms include:

- Better information about CCRTA services, including real-time information on bus locations/arrival times via the Internet or by calling the operations center, may encourage more people to use the transit services;
- Operational improvements, such as improved on-time performance or a reduction in the advance time needed to schedule a paratransit trip, could encourage more people to use the transit services;
- Over the longer term, the AVL data may facilitate the restructuring of routes or services to serve more passengers; and
- The magnetic stripe fare cards, introduced under Phase 3 of APTS deployment, increase convenience for transit users and provide a user-side subsidy. In addition, they were distributed in conjunction with marketing efforts to increase awareness of CCRTA services.

Table 5.6 summarizes the extent to which data are available to assess the potential impacts of each of the mechanisms described above on ridership.

The Hyannis area route restructuring appears to be the only change related to APTS Phase 1 and 2 implementation where measurable ridership impacts might be expected that can be related to the APTS project. Impacts observed as a result of the Phase 3 Cape Cod Transit Tourist Pass (CCTTP) program also are discussed.

Table 5.6 Data Available to Assess Ridership Impacts of APTS

Mechanism by Which APTS Could Affect Ridership	Availability of Data
Better customer information	Data are not available to assess this factor
Improved operations	Operational impacts experienced to date are relatively small; significant ridership impacts are not expected
Service changes	One significant example of route restructuring (in the Hyannis area) can be evaluated
Electronic fare payment	Some data on use of EFP in summer 2001, but insufficient information to relate EFP use to ridership increases

Hyannis Area Route Restructuring

As previously discussed, routes were restructured in the Hyannis area, starting in summer 2001, based largely on the availability of AVL passenger boarding and disembarking data. Some additional Sunday service also was introduced in the area at the same time. To investigate potential ridership changes in the Hyannis area, ridership data by route were evaluated for summer 1999, 2000, and 2001. The purpose of looking at ridership across all routes during this period was to place changes in ridership in Hyannis in context, i.e., to look for other ridership trends and patterns that may have influenced ridership in Hyannis independent of the route restructuring. The summer period was evaluated because this was the only season for which post-restructuring data were available at the time of the analysis. July and August, in particular, were isolated because these months represent complete months of summer service. June and September are "transition" months where the hours and frequency of service vary and also where the level of service changed on many routes for 2001 compared to 2000. These data should be reviewed keeping in mind the data quality issues experienced in summer 2001, as described above under "Data Management."

Table 5.7 shows a net ridership increase of 16 percent (4,060 riders) in the Hyannis area in summer 2001 compared to summer 2000. At the same time, revenue-hours increased by 35 percent, from 4,095 to 5,518. This ridership increase, therefore, came at a slight loss in service productivity, from 6.04 to 5.22 passengers per hour.

Table 5.7 Fixed-Route Summer Ridership (July and August) for 1999-2001

Year	SeaLine and H2O	Hyannis Area (All Routes)	Provincetown Shuttle	Other Trolleys	Total Except Provincetown and Hyannis	All Routes
1999	12,349	25,407	0	50,444	88,200	88,200
2000	10,114	24,717	48,465	46,331	81,162	129,627
2001	16,272	28,777	71,816	39,421	89,926	161,742
Change						
1999-2000	-2,235	-690	48,465	-4,113	-7,038	41,427
2000-2001	6,158	4,060	23,351	-6,910	8,764	32,115
Percent Change						
1999-2000	-18%	-3%	N/A	-8%	-8%	47%
2000-2001	61%	16%	48%	-15%	11%	25%

The ridership increase in Hyannis can be compared to the system as a whole, which experienced a net increase in ridership of 25 percent or 32,115 riders. However, this includes a substantial ridership increase on the Provincetown Shuttle, where service frequency was increased and awareness of the service likely grew in its second year of operation. Excluding the Shuttle and the Hyannis routes themselves, the ridership increase on the remainder of the system was 8,764 or 11 percent. Therefore, ridership appears to have increased in Hyannis at a slightly greater rate than would have been expected without the restructuring.

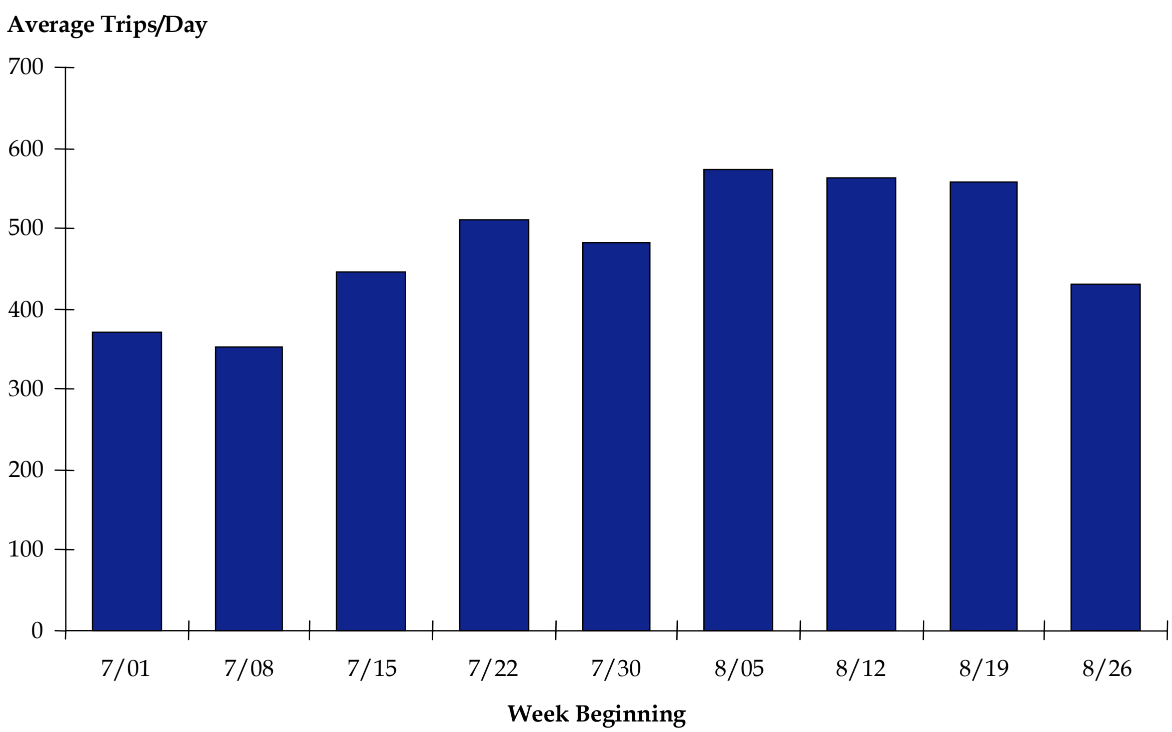
Some of the overall increase on the Hyannis area routes, SeaLine, and H2O is probably due to the addition of Sunday service. Compared to the net increase of 4,060 riders on the Hyannis routes between summer 2000 and summer 2001, there were approximately 3,300 Sunday riders during July and August. Sunday service was not previously provided on the Villager, SeaLine, or H2O, although it was provided on the summer trolleys, including the Hyannis Area Trolley.

Ridership data on Hyannis area services also were compared for October through December 2000 and 2001. Combined Villager and Bearse's Way ridership during this period of 2001 was 12,344, an increase of 74 percent over Villager ridership of 7,089 for the same period in 2000. At the same time, there was an increase in revenue-hours of service of 70 percent. Therefore, it appears that the restructuring was successful in creating a significant increase in ridership during the off-season in the Hyannis area, while slightly increasing service productivity (from 4.53 to 4.64 passengers per revenue-hour). For comparison, the combined ridership increase on the SeaLine and H2O lines was 22,860 passengers or 28 percent during this period, with productivity increasing from 4.80 to 5.52 passengers per revenue-hour.

Cape Cod Tourist Transit Pass

It is likely that the introduction of the tourist transit pass (part of the Phase 3 APTS deployment) led to an increase in ridership in summer 2001 and 2002, because this pass was given away for free in conjunction with marketing efforts promoting CCRTA services. The actual number of transit tourist pass riders in summer 2001 is unknown as a result of data problems experienced during this period. Field reports also indicated that CCRTA drivers did not require Cape Cod Tourist Transit Pass holders to swipe the card on a consistent basis upon entering the vehicle. Universally, the pass holders never swiped the card upon leaving the vehicle. Therefore, the MDC data on card users from summer 2001 are generally viewed as unreliable. The data from summer 2002, which are believed to be more reliable, show 29,559 transit pass trips taken during July and August, including 24,432 on the Provincetown Shuttle. The average daily number of pass trips by week during July and August 2002 is shown in Figure 5.8.

Figure 5.8 Transit Tourist Pass Ridership by Week
Summer 2002



As detailed in Appendix B, data from a survey of transit tourist pass users, combined with pass usage data from the MDC, can be combined to estimate the potential range of new transit trips that can be attributed to the Tourist Transit Pass program. This estimate ranges from 7,500 to 20,000 trips during July and August, depending upon the assumptions made. These estimates represent between five and 12 percent of all fixed-route transit trips on the CCRTA system during this period.

It should be noted that most of the pass usage (about 85 percent) has occurred on the Provincetown Shuttle, and ridership on this route has increased substantially over its three years of operation. Total ridership on the Shuttle during July and August increased from 48,465 in 2000 to 71,816 in 2001 to 92,500 in 2002. This is probably the result of a number of factors in addition to the tourist pass. First, in summer 2001 the frequency of the shuttle service was increased from published 30-minute to 20-minute headways. Some changes were made to the routing of the shuttle to serve an additional high-traffic destination (a campground). Also, awareness of the service has probably continued to increase over time.

Service Productivity

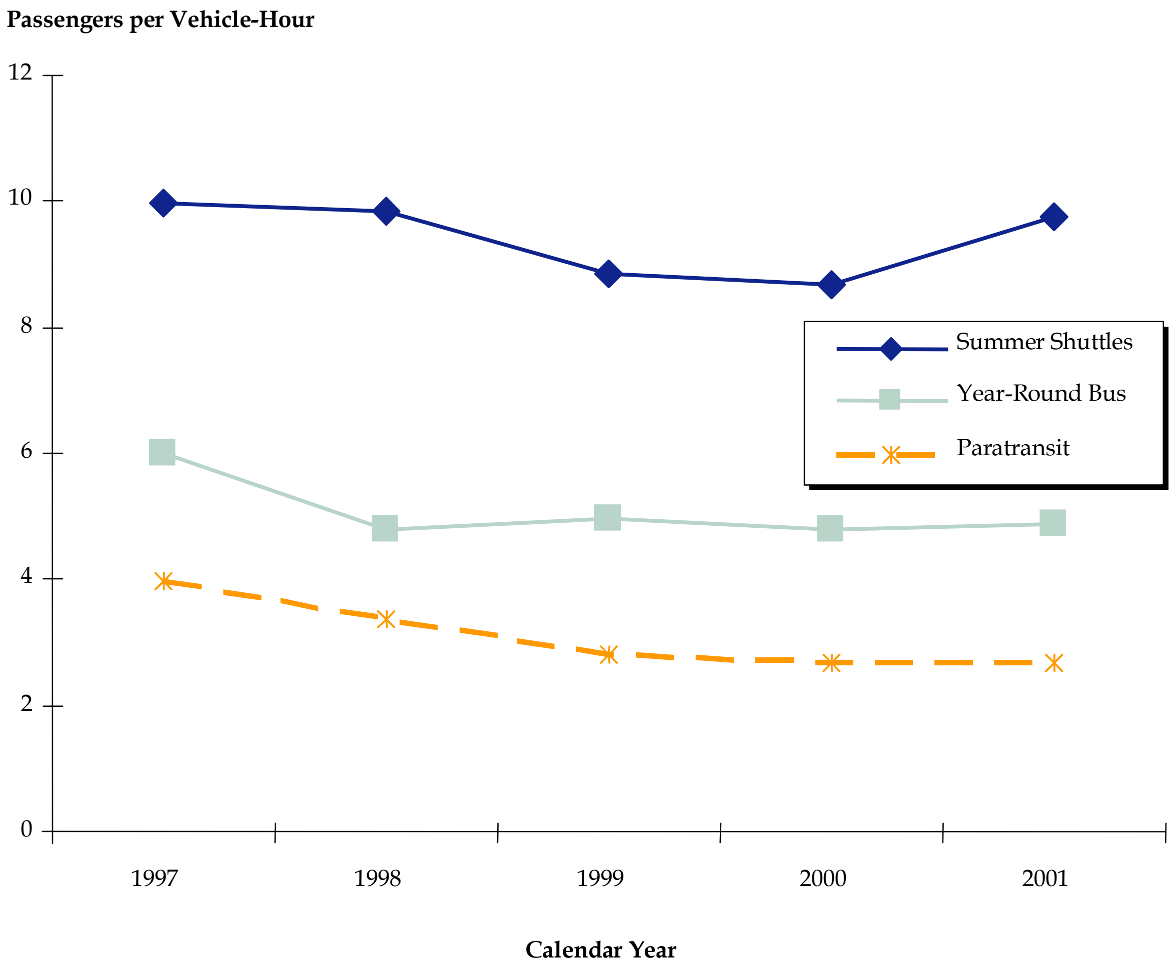
Service productivity is a fundamental measure of interest to the transit agency. The number of passenger-trips or passenger-miles accommodated per vehicle-hour, in particular, is a key driver of the amount of service that is being provided per unit cost.[7] Figure 5.9 illustrates trends over the past five years in CCRTA service productivity for fixed-route and paratransit services, as measured by passenger-trips per vehicle-hour. The numbers underlying this figure are provided in Table 2.3. The data show a slight decline in summer shuttle service productivity in 1999 and 2000, which reversed itself in 2001. Year-round fixed-route and paratransit service productivity each remained roughly constant between 1999 and 2001. As a result, overall year-round service productivity, including fixed-route and paratransit combined (not shown) increased slightly, from 3.99 passengers per vehicle-hour in 2000 to 4.29 in 2001, because of a shift in passenger volumes from paratransit to fixed-route.

As with ridership, many factors in addition to the APTS system may affect service productivity over time. Again, it is helpful to consider the specific mechanisms by which APTS could potentially affect productivity. Service productivity for an agency such as CCRTA may be increased in three ways:

---

[7] Service productivity, as defined here, is not to be confused with overall productivity (cost per unit of service) as defined in the National ITS Program goals.

Figure 5.9 Service Productivity Trends



1. Increasing the number of passenger-trips that can be accommodated per vehicle-hour on the paratransit system;

2. Increasing ridership on fixed-routes without a proportional increase in fixed-route service; and

3. Shifting riders from paratransit vehicles to existing fixed-route services, or to new fixed-route services where productivity is higher than for paratransit services.

To date, there appear to be few changes made possible by the APTS that would facilitate either a significant increase or decrease in service productivity. The APTS does not appear to have changed paratransit operating practices in such a way that more trips can be accommodated (e.g., through more efficient vehicle routing). The provision of real-time bus location information via the Internet could potentially have increased transit ridership, but data were not available to assess this impact. With the possible exception of ridership increases induced by the Cape Cod Tourist Transit Pass program, it does not appear that any significant, systemwide impacts on fixed-route ridership can be observed.

Examining ridership in a smaller geographic area, it was hypothesized that the restructuring of the Hyannis area fixed-routes implemented in summer 2001 would allow the shift of some trips from paratransit to fixed-routes. The routes were reconstructed in such a way as to serve areas where high paratransit trip origins and destinations were noted. The restructuring was facilitated in part by data made available through the APTS system. The systemwide data suggest an overall shift from paratransit to fixed-route in 2001, but are insufficient to associate this shift with service changes in the Hyannis area.

To specifically examine ridership in the affected areas of Hyannis, geocoded paratransit trip origins and destinations in the Hyannis area would ideally be available for an equivalent time period both before and after the route restructuring. (Also, ideally, some time would be allowed to lapse to allow for people to become familiar with the new routes.) However, geocoding trips after implementation of the restructuring would have been labor-intensive and was beyond the scope of the current study. Instead, an attempt was made to compare trends in overall monthly paratransit ridership in the Hyannis area. The primary drawback to this approach is that Hyannis is actually part of the town of Barnstable, which covers a much larger area. Therefore, a significant fraction of paratransit customers in Barnstable would not live in proximity to the route restructuring. Without geocoding addresses, paratransit ridership data are not available for spatial units smaller than the town level.

To test the hypothesis that paratransit ridership decreased as a result of fixed-route restructuring, a regression model was created on monthly paratransit ridership data for the town of Barnstable, from January 1996 through December 2001 (one month, May 2000, was suspiciously low across all towns and was eliminated). A time-trend variable was included, with the unit of time being monthly, as was a dummy variable representing route restructuring (this variable is one if the month is June 2001 or later, zero if before this date). A seasonal dummy variable was introduced for the months of November, January, and February, which typically have low ridership. The regression results showed that the restructuring variable is not statistically significant. It should also be noted that only seven months of data were available after the restructuring, which may not be a long enough time period to observe a shift in ridership trends. Therefore, this data set is inconclusive regarding whether the restructuring of Hyannis area routes has led to a shift in ridership from paratransit to fixed-route.

Figure 5.10 shows the trend in Barnstable paratransit ridership with a simple trendline superimposed. Table 5.8 shows the results of the regression analysis.

Figure 5.10 Trend in Barnstable Paratransit Ridership

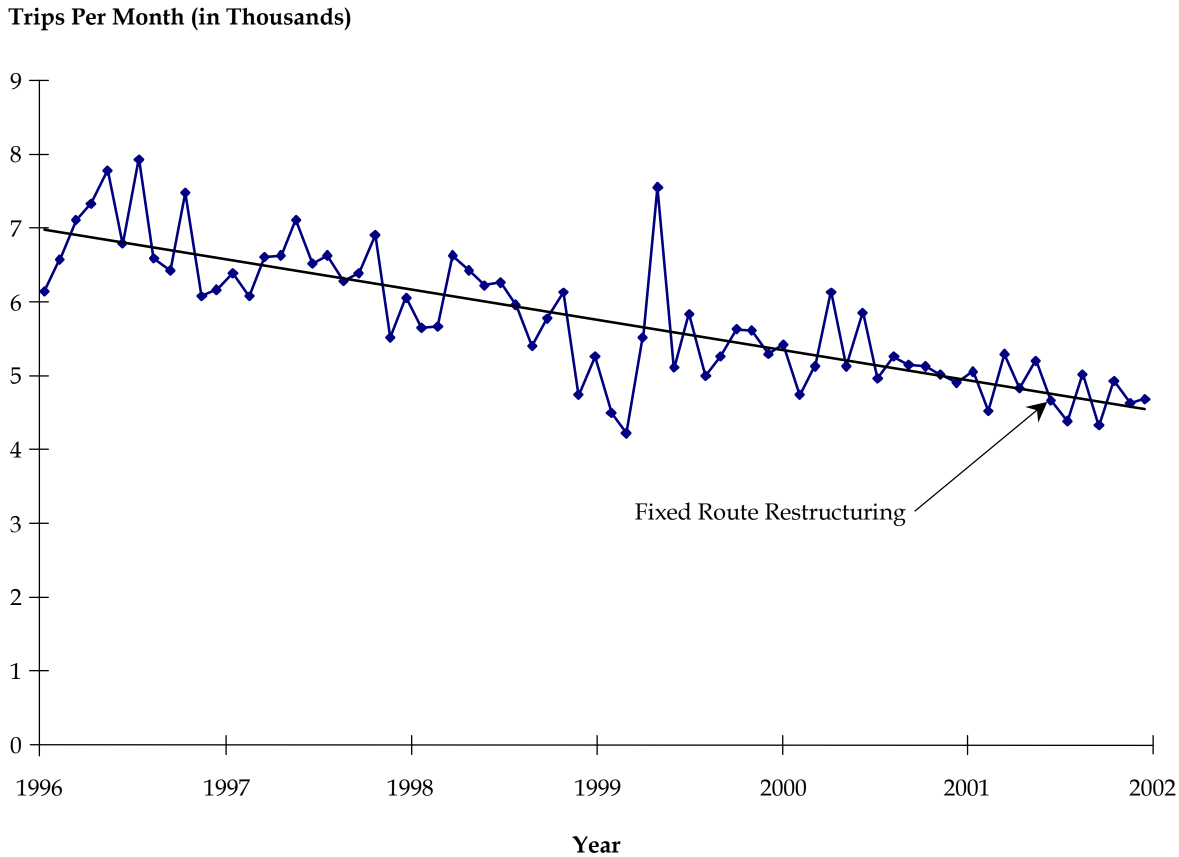


Table 5.8 Results of Regression Analysis for Barnstable[1]

	Coefficient	t-Statistic
Intercept	7418	55.6
Time-Trend	-33.7	-11.2
Restructuring Dummy (1 if after May 2001)	-56.5	-0.27
Seasonal Dummy (1 if November, January, or February)	-654.0	-5.30

[1] The coefficient indicates the direction and magnitude of the variable. The t-statistic indicates whether the variable is significant; a t-statistic of roughly 2.0 or greater indicates that the variable is statistically significant at the 95 percent confidence level. In this analysis, ridership declines with time (33.3 riders per month) at a statistically significant level. The restructuring variable is not statistically significant.

Service Costs and Efficiency

Service efficiency can be defined as service provided per unit cost. Service efficiency is determined in part by service productivity, but costs also are affected by factors such as wage and benefit rates and administration and management. Efficiency can be viewed at two levels:

1. The **marginal cost** of operating a unit of service (e.g., a vehicle-hour), reflecting the vehicle operator's wage and benefits; insurance;[8] vehicle fuel, oil, and maintenance; and the amortized capital cost of the vehicle; and,

2. The **average cost** to the agency of operating the same unit of service, which also includes such items as dispatcher, maintenance, management, and administrative staff salary and benefits, office rent, and equipment and supplies. These additional costs may vary depending upon the amount of service provided (e.g., more service may require more dispatchers), but changes in these costs tend to be "lumpy" (moving to a new office or hiring another staff person) rather than directly varying with the amount of service provided.

In the case of CCRTA, the Authority contracts with an outside agency, CATS, to provide transit service. Only administrative staff are employed directly by the Authority; operations management, dispatchers, and maintenance staff are employed by CATS at a separate operations center. However, CCRTA subcontractors operate on a cost-reimbursable basis, so that savings in costs to CATS are reflected in cost savings to CCRTA.

Marginal Cost of Service

For the most part, aside from the potential service productivity impacts noted above, the APTS system does not appear to have significantly affected the marginal cost of transit service provision. There is no obvious reason why it would affect vehicle operator wages or benefits, insurance costs, or vehicle fuel and oil consumption. There may be a small impact on the staff time required to maintain the vehicle-based APTS equipment, but the total APTS-related maintenance effort – once the system is installed and working properly – is reported by CCRTA to be only a couple of hours a month. Other maintenance costs are covered under a service contract with the MDC vendor which is structured on a per-unit basis.

The one impact that the APTS appears to have had to date on the cost of service is by assisting CCRTA in identifying alleged fraud on the part of a service provider. After comparing APTS data on actual with reported vehicle-miles of service and on the routing of vehicles, CCRTA terminated the service provider's contract. CCRTA and the contractor did not reach agreement upon the existence or magnitude of any difference in service

[8] Insurance could be considered a marginal or average cost depending upon how the insurance contract is structured. In Massachusetts, rates are set by the State and are related directly to the number of vehicles in service, but only marginally to the miles traveled per vehicle.

provided versus service billed, however, so data to quantify the benefits to CCRTA are unavailable. As a result, it is difficult to directly translate the benefits provided by this oversight function into a cost savings to the agency or an improvement in service quality to the customer.

Average Cost of Service

The Cape Cod APTS system might be expected to influence the overall average cost and efficiency of CCRTA's in two primary ways. These include:

1. The direct monetary costs of the APTS system, including both capital and operating costs. Capital costs may include software, dispatch center hardware, in-vehicle hardware, and other hardware (e.g., radio transmission system). Monetary operating costs may include expenditures on maintenance contracts, parts and outside labor, and data transmission.

2. Savings or increases in staff time spent on various tasks, as a result of the system. Some initial investment of staff time is required to become familiar with the technology, procure, and install equipment, etc. This can be considered the equivalent of a capital expenditure in that it is a one-time, up-front cost. The Cape Cod APTS also may affect the time spent by staff on various repeated tasks. These include (but are not limited to):

   – Dispatchers preparing and distributing schedules;

   – Dispatchers answering calls and responding to customer requests;

   – Dispatchers communicating with vehicle operators;

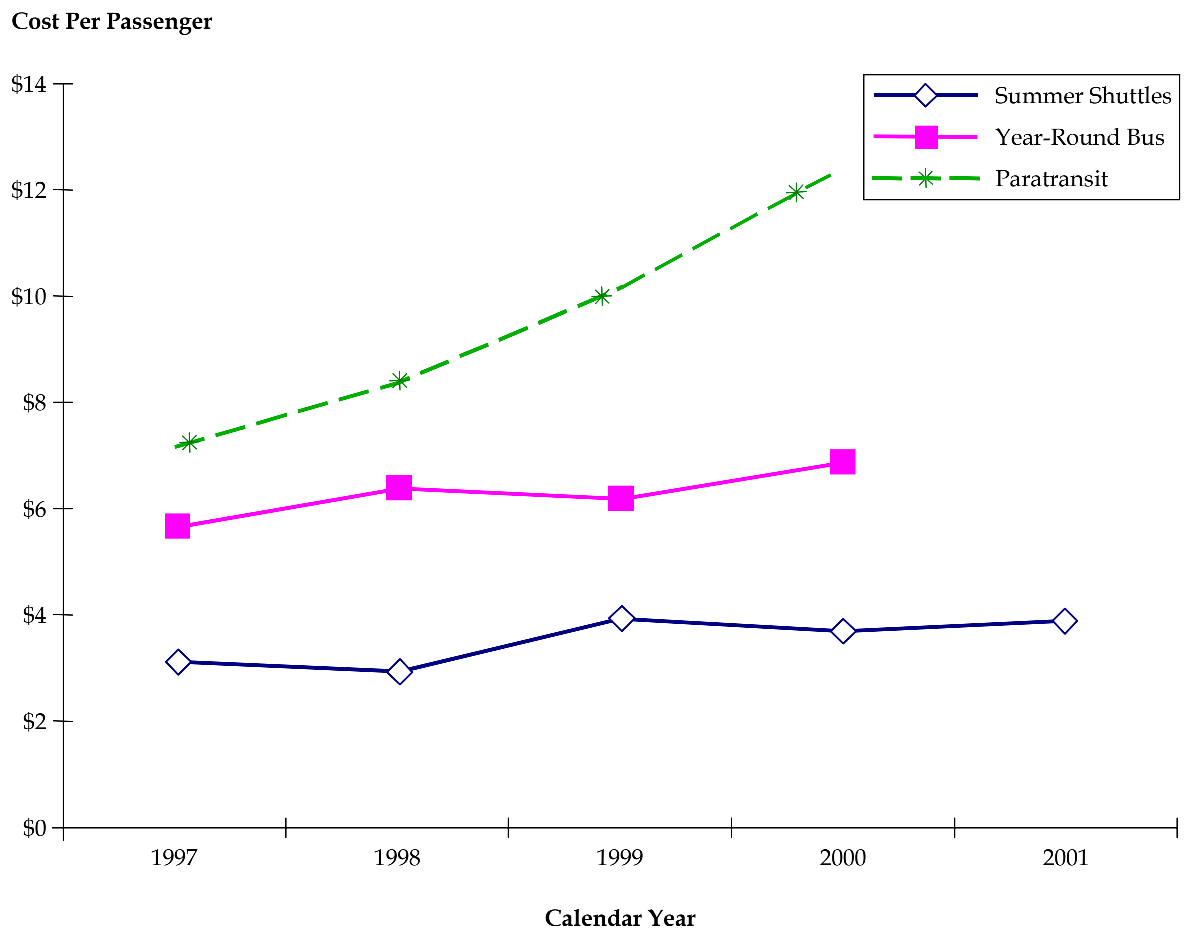
   – Data entry and analysis;

   – Hardware and software maintenance activities; and

   – Training for new staff, for example, training time for new dispatchers to become familiar and efficient with scheduling and routing procedures.

Figure 5.11 illustrates trends in service costs and efficiency, as measured in cost per passenger, over the years 1997 through 2001 (the numbers underlying this figure are shown in Table 2.3). A slight increase over this period would be expected due to inflation. It appears that the cost per paratransit trip increased most significantly (consistent with the decline in trips per vehicle-hour). The cost per passenger on the summer shuttles actually held constant in real terms from 1999 through 2001. Cost data for year-round service for the second half of 2001 were unavailable at the time of this writing.

Figure 5.11 Trends in Cost Per Passenger



Similar to the analysis of ridership data, many factors preclude a definite linkage of any of these cost and efficiency trends to the APTS system. These factors include changes in contracts for providing service from year to year, and especially wage rates; changes in the price of gasoline, oil, and parts; and changes in the amount of service provided (when looking at total route costs).

Capital costs, operating costs, and estimates of staff time related to the APTS system are discussed in Section 5.3 and are compared to the overall magnitude of the CCRTA capital and operating budget. This comparison provides an indication of the magnitude of impact of APTS costs on CCRTA's average operating cost. While CCRTA obtained grants to pay for the capital costs of the APTS project, this evaluation focuses on the overall cost of transit service provision, rather than considering who paid for the service.

5.5 Potential Benefits to the CCRTA Customer

Potential areas of benefit to the CCRTA customer include:

- Customer information;
- Paratransit trip scheduling;
- On-time performance;
- Trip travel times; and
- Safety.

Customer Information

The AVL provides information on the real-time location of buses, which is made available to the public through a variety of methods. One of these methods is by calling the dispatch center. As previously noted, AVL allows dispatchers to more easily respond to customer inquiries since they can view the location of the bus on the computer screen, rather than having to call the bus to obtain its location. Dispatchers estimate that they respond to such inquiries a few times an hour in the summer and a few times a day in the off-season. Most of their inquiries in the summer are from tourists unfamiliar with the schedules. Dispatchers also noted that paratransit customers call and ask for an estimated time of arrival (ETA) a few times a day. In some cases, they use the AVL, while in others they will either radio the operator or send a message via the MDC asking whether the operator can provide an ETA. The operator can send a yes/no response via the MDC and then is supposed to call if they are able to provide an ETA.

To assess the frequency of customer information requests, dispatchers were asked to record the number of calls they received by purpose for a one-week period in February 2002. Table 5.9 shows the results of this assessment. On an average day, dispatchers answered a total of about 30 inquiries regarding the expected arrival time of a bus, with about two-thirds of these inquiries for the B-Bus (paratransit). Similar data were not available for the summer tourist season.

Table 5.9 Customer Information Requests
February 2002

Type of Information Requested	Average per Day
Real-Time Bus Information (B-Bus)	20
Real-Time Bus Information (Fixed-Route)	10
Other Information	39
Total	**69**

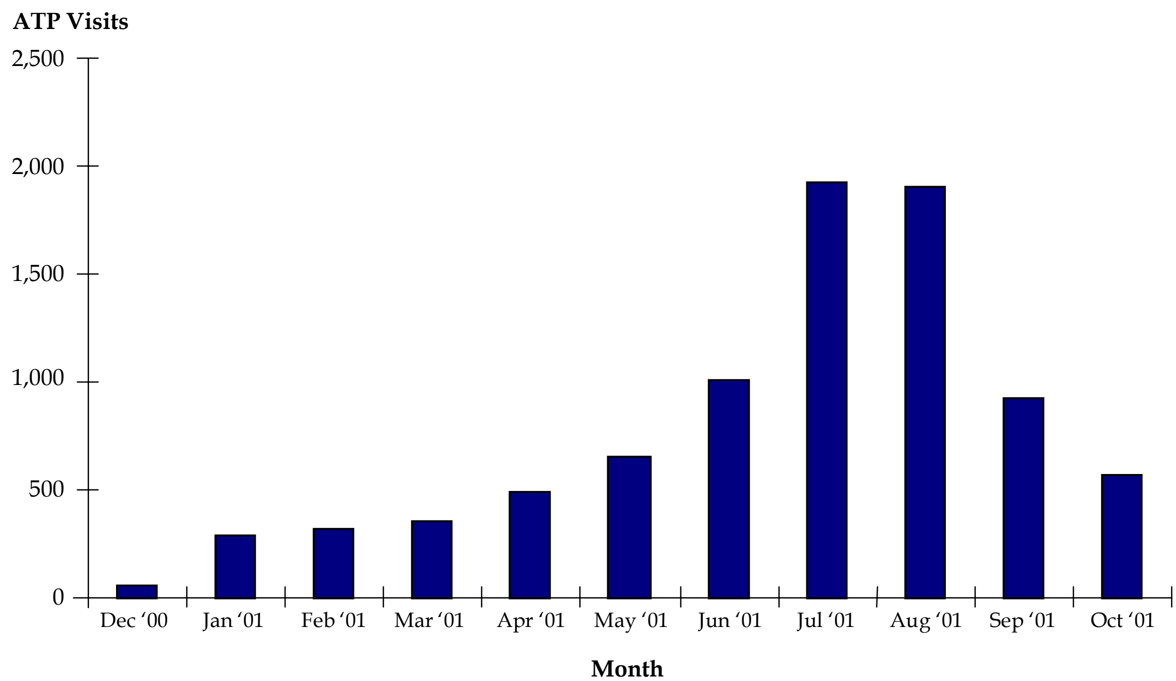
The AVL is also at the core of a larger customer information initiative undertaken by the Moakley Center in conjunction with CCRTA. The Center has developed an Advanced Travel Planner on their web site (www.e-transit.org) which includes a map showing the real-time location of buses. The ATP also includes the option for the user to select an origin and destination; the server plots these locations on a map of the CCRTA bus routes, and the user can select a bus route to view schedules. Beginning in 2002, the ATP may be made available at public locations on the Cape, including kiosks in hotels participating in the Cape Cod Tourist Transit Pass Program and a new intermodal transit center being constructed in Hyannis.

Only limited information is currently available on the utilization and value of this information to customers of CCRTA. Figure 5.12 shows "hits" to the ATP web site during summer 2001, which peaked at nearly 2000 hits per month in July and August. The number of hits per month prior to May 2001 and in October 2001 (500 or less) suggests that at least three-quarters of the hits to the ATP web site may be from visitors to the Cape.

The need to access a computer to view this information currently represents a limitation on the extent of its usefulness, especially for customers of CCRTA who may not own a computer or do not have access to one at their origin or destination. However, as noted, anyone with access to a telephone may contact the dispatch center to obtain an estimated arrival time.

Dispatchers also use the playback capability to check after-the-fact questions and complaints from customers. For example, they have used it to verify that a vehicle was actually on time at the proper location, whereas the customer was waiting on the other side of the building from the stop location. In this function, the AVL can be used to clear up confusion between the customer and CCRTA regarding a pick-up point. CCRTA also has used the AVL to check complaints about speeding buses through neighborhoods.

Figure 5.12 Hits to the Advanced Travel Planner Web Site



Source: Cape Cod Regional Transit Authority; GeoGraphics Laboratory, Moakley Center for Technological Applications, Bridgewater State College; and Cape Cod Chamber of Commerce. "Cape Cod Tourist Pass Program – e-transit comes to the Cape." November 2001.

Paratransit Trip Scheduling

The potential benefits to paratransit clients of APTS have been discussed in Section 5.2. As noted, CCRTA has not changed its 11:00 a.m. previous-day deadline for scheduling paratransit trips, and it does not appear that a larger number of last-minute trip additions or changes are being accommodated as a result of the APTS.

CCRTA believes that in the long term, the combination of electronic manifest communication via the MDCs and a computerized routing and scheduling program could potentially reduce the advance-scheduling window to three to four hours. However, operations staff and management need to feel completely comfortable with both the reliability of the MDCs and the capabilities of an automated routing/scheduling program before making this conversion. To date, automated routing/scheduling has not been implemented at CCRTA because management feels that dispatchers and operators are able to perform well at this function based on their knowledge of the local area. Also, as previously noted, operations staff do not believe the MDC system is 100 percent reliable in communicating trip data and feel that they will need to rely on paper manifest distribution as a back-up for the indefinite future.

On-Time Performance

The potential impact of the APTS system on on-time performance also has been previously discussed in Section 5.2. As noted, none of the operations staff felt it has helped improve the timeliness of paratransit vehicle pick-ups and drop-offs. It does have some theoretical benefits for fixed-route on-time performance, by allowing closer observation of vehicles (giving operators a greater incentive to maintain schedule), greater control of vehicle spacing under congested traffic conditions, and long-term adjustments to routes and schedules if published schedules are not consistent with practical travel times. It appears that information provided by the AVL in its first year of implementation, 1998, led to limited operational changes that included occasionally holding over late buses to the start of the next run on the summer trolley routes. However, before-and-after data to assess the frequency of this practice and its potential impact on on-time performance are not available.

Between summer 2000 and 2001, when AVL was installed on all buses, operations staff does not feel that there has been a significant difference in operational practices to date, or that on-time performance is likely to have improved. A sample of data from this period also did not show any obvious effect. In the future, the data collected by the AVL system will allow much closer tracking and analysis of on-time performance on a routine basis.

Trip Travel Times

Similar to on-time performance, the APTS would not appear on a regular basis to reduce trip travel times. It has had no apparent effect on paratransit trip routing or scheduling practices. It also generally does not have the capability to lead to shorter fixed-route trip travel times.

Two service changes that were made partly based on APTS data, however, may have improved travel times for specific customers on the CCRTA system. In one case, AVL data were used to help confirm anecdotal observations that the SeaLine route had too much time allotted. As a result, the scheduled run time on the SeaLine route was reduced by one to three minutes (depending upon the run and direction), a savings of 1.1 to 3.5 percent of total route travel time.

In the other case, routes were restructured in the Hyannis area based in part on boarding and disembarking data provided by the AVL/MDC. The extent to which this restructuring made trips more (or less) efficient for local customers cannot be determined without a detailed evaluation of origin-destination data from the area. Total ridership in the area, however, did increase, suggesting that the route restructuring did provide a net benefit to travelers.

Safety

The safety benefits of the APTS to CCRTA customers are related to the safety benefits to vehicle operators. As previously noted, there was one case in which an operator was threatened with a knife and was able to press the silent alarm to notify dispatch, and another in which help was summoned to remove a drunk and disorderly passenger. In these cases, no passengers were injured, but the potential exists for the alarm to deter incidents or summon help more quickly in a problem situation. Also, the potential exists for the AVL to help dispatch locate a vehicle more quickly and summon help in case of a medical emergency on the part of a passenger.

Other Benefits

Customer convenience and cost have been affected through the pilot implementation of the "tourist pass" program for fixed-route customers in summer 2001 and 2002, included as part of Phase 3 of the Cape Cod APTS deployment.[9] Under this program, funded by a CMAQ program grant, free magnetic swipe cards were distributed to visitors at participating hotels within a one-quarter-mile radius of CCRTA fixed-routes. Cards also were distributed to hotel employees as an appreciation of their services in recruiting visitors and logging visitor information. In both summer 2001 and summer 2002, over 5,000 cards were distributed to registered guests and hotel workers and were recollected when guests turned their keys back in. While 18 hotels distributed passes in 2001 and 25 participated in 2002, the great majority (nearly 90 percent in summer 2002) of the cards were distributed in Provincetown, primarily by three hotels. Also based on data from summer 2002, about 84 percent of pass usage was by guests (visitors to the Cape) while the remaining 16 percent was by hotel staff.[10]

For visitors and employees of hotels participating in the tourist pass program, CCRTA believes that the magnetic stripe card program was a success in attracting riders and increasing the convenience of transit travel. CCRTA also reports that customer feedback was very supportive of the program. One anecdotal example of this was a family from England who had forgotten their drivers' licenses and were pleased to find the trolley service available. In general, people relying on walking/cabs/transit will use the trolley if they see it, but they will not wait for the trolley if they do not know it exists or if they do not have a schedule. According to CCRTA, the magnetic stripe card program provided the publicity to the trolley service to make it more successful.

---

[9] Cape Cod Regional Transit Authority; GeoGraphics Laboratory, Moakley Center for Technological Applications, Bridgewater State College; and Cape Cod Chamber of Commerce. *Cape Cod Tourist Transit Pass Program – E-Transit Comes to the Cape*. November 2001.

[10] This figure is based on the 70 percent of card swipes that could be attributed to either staff or a guest; the remaining 30 percent could not be attributed.

CCRTA and Moakley Center staff reported that the program was particularly successful in Provincetown where many tourists take high-speed ferries from Boston and do not bring a car as parking in Provincetown can be very difficult. The program was less successful in Hyannis and Falmouth where people tend to use cars to get around.

5.6 Potential Benefits to Others

Potential benefits to others, aside from CCRTA and its customers, include reductions in vehicle trips and associated emissions.

The Phase 1 and 2 APTS deployment does not, at this point, appear to have had a quantifiable effect on transit ridership or a corresponding decrease in private vehicle trips and emissions. The APTS equipment does not yet appear to have significantly affected the quality of CCRTA's service, as viewed by the customer, and therefore a significant ridership increase would not be expected. The benefits of additional information provided by the Internet Advanced Travel Planner may have encouraged some additional riders to use the CCRTA transit system, but if so, this change cannot be measured using available data.

It is more likely that the Cape Cod Transit Tourist Pass program introduced in summer 2001, a part of the Cape Cod APTS Phase 3 deployment, may have encouraged some people (including visitors to the Cape and hotel employees) to use transit instead of driving. Over 31,000 trips using the transit tourist pass were recorded during summer 2002. As described in Appendix B, the pass program was estimated to result in a decrease of between 1,700 and 4,700 vehicle trips, as well as providing corresponding reductions in VMT and emissions.

5.7 Anticipated Future Benefits

CCRTA is incrementally adopting functions of the APTS system. As of yet, they have not fully tapped into the system's capabilities. Potential future expansions and enhancements of the system as well as use of system-generated data include:

- Expansion over a broader service area, to improve convenience for customers;
- More extensive use of electronic fare payment technology and capabilities;
- Decreased advance notice for paratransit trip scheduling;
- Enhanced real-time customer information; and
- Additional analysis of ridership patterns and service routes.

Some of the potential benefits of these additional capabilities are described below.

Service Area Expansion

The Cape Cod APTS steering group envisioned eventually covering the entire southeastern portion of Massachusetts. They are currently in partnership with the adjacent GATRA and envision partnerships with other service providers, such as ferries to Martha's Vineyard and Nantucket and long-distance bus and rail service to Boston, Providence, and New York City. Goals of this program include area-wide customer information as well as an integrated farecard. One implementation barrier is the need to build repeaters on the islands for the data channel. Attempts at greater regional integration also have been limited by institutional issues. For example, CCRTA approached the Plymouth & Brockton Company, which provides long-distance service on the Cape and to Boston, to install AVL and MDC units on their vehicles to make use of EFP technology, but the company was not interested at the time.

Electronic Fare Payment

The use of EFP could be expanded through expansion of the magnetic stripe card program and/or introduction of stored-value "Smart Cards." EFP has the potential, if expanded, to reduce the administrative burdens of billing for paratransit trips and fare collection for fixed-route trips.

Currently, for paratransit trips to be billed to a human service agency (HSA), the dispatcher who schedules the trip enters an HSA code and bills are generated by accounts payable software integrated with Transit for Windows. Trips paid for by individuals, however, are billed through a monthly invoice to that individual. Administrative staff must manually review paratransit manifests to determine the number of trips taken by an individual, their origins and destinations, and the appropriate fee to charge to that individual or HSA. The CCRTA bookkeeper currently spends about 40 percent of her time on paratransit billing, including writing invoices to customers. With an expanded electronic fare payment capability, the fare card could be coded with the HSA for which the passenger is a client, and the trip automatically stored as a trip to be billed to a specific HSA. With a Smart Card, customers could purchase or add value to the card and use it for trips, eliminating the need for the agency to bill the customer.

For fixed-route trips, EFP has the potential to reduce the administrative effort by CCRTA involved in handling money, by reducing or eliminating cash fare payments. CCRTA also is exploring opportunities to provide taxicabs with the same technological features available to the buses. As a long-term objective, CCRTA wants to use a Smart Card system to establish fare structures that encourage people to switch from paratransit to fixed-route trips when feasible, to increase the overall efficiency of CCRTA's service provision. The cards also enable the use of user-side subsidies (such as tested in summer 2001) to encourage visitors to the Cape to use transit instead of driving.

While increased use of EFP is an important objective for CCRTA, the agency has not yet made a decision on the best technology. The current magnetic stripe cards have the advantage of being compatible with the Mentor MDCs installed on the vehicles.

However, the MDCs cannot currently accommodate a stored-value "Smart Card" which is required for policies such as distance- or location-based pricing of fixed-route trips. Also, the physical design (in which the card must be handed to the operator) may be less convenient than one in which the passenger can swipe the card. One barrier to expanded implementation of EFP is the potentially significant effort involved in establishing a mechanism for distributing stored-value cards.

Paratransit Trip Scheduling

If the Authority is able to develop a scheduling optimization algorithm in conjunction with real-time messaging via the MDC, they may be able to evolve from a 24-hour advance-notice system to a three- or four-hour system. While this is a longer-term objective of the Cape Cod APTS project, fully electronic trip scheduling is required to accomplish this. Customers will benefit by the need for less advance time to schedule a trip.

Customer Information

Researchers at Bridgewater State College successfully tested an estimated time of arrival algorithm in summer 2001, which relies on AVL data. Initially, this information could be disseminated to customers via the Internet site, kiosks in public areas, and telephone calls to dispatchers. In the long run, this information could be made available via text messaging through cellular telephones or a network-enabled personal digital assistant (PDA).

Additional Data Analysis

The geocoded vehicle location and boarding and alighting data provided by the MDCs is potentially useful for reassessing the locations of individual stops and routes as well as the timing of these routes. CCRTA plans to continue to explore these data and their implications in the future. The AVL is already being used to track the on-time performance of buses on a routine basis.

The MDC system does not record latitude and longitude coordinates for boarding and disembarking paratransit customers without specific action by the operator, but such information would be extremely useful for service planning. Staff and students at Bridgewater State College have undertaken a project to geocode major origins and destinations on the Cape, which are included in the Advanced Travel Planner. Since trip origins and destinations are archived in the MDC database, this effort will help make paratransit trip data more usable for spatial analysis purposes.

5.8 Training

The amount and quality of training provided to dispatchers and operators in the use of the APTS equipment has the potential to affect how the equipment is used and how it benefits the agency. The levels and perceived adequacy of training were determined through interviews with dispatchers, operators, and management. It should be noted that these interviews were conducted in November 2001, which is a minimum of seven months and possibly up to three years after the staff person initially received training with the equipment, depending upon the position. (Dispatchers started using the AVL in summer 1998 and the MDC in summer 1999. Fixed-route operators may have had experience with the MDC as early as summer 1999, or as late as May 2000. Paratransit operators probably did not use the MDC until May 2000 or later.)

According to management, training was initially performed by the contractors (Mentor and their subcontractor TriStar), who trained all the dispatchers and a nucleus of operations people, who could then train bus operators. Initially, three to four fixed-route and three to four paratransit operators were given pilot training. MDC desk models were set up to conduct the training in the lab rather than in the field. The operators "picked it up pretty quickly" and all of the areas were covered in about one day for the 12 year-round fixed-route operators. Paratransit training was more complicated and required about two days of total training time to cover the 40 year-round paratransit operators.

Dispatchers appeared comfortable with using the basic functions of the AVL/MDC equipment, such as messaging using the MDCs, but were not always comfortable with some of the more advanced functions, such as the run playback of the AVL software. The perceived adequacy of initial and ongoing training among dispatchers varied by dispatcher. Discussions with management suggest that dispatchers are receiving additional training in the use of the AVL features during winter 2001/2002, as they are asked to do more with the system, such as track on-time performance.

The operators interviewed, all of whom are permanent employees, generally expressed comfort with their ability to use the MDCs. They felt that the level of training, typically a half-hour or less, was adequate (they also received a written manual), or that they had been able to pick up the necessary features on their own. Some of the operators noted that they did not remember some of the more complex functions, such as alternative function keystrokes that can make certain operations easier, or shortcut codes for messages. This does not restrict their ability to use the MDC for its basic functions, but may discourage some from using optional functions such as canned message replies to the dispatch center.

During the summer months, CCRTA hires an additional 40 to 50 operators as temporary help. In 2001, two road supervisors trained the fixed-route summer shuttle drivers. MDC training was included as part of this training. Administration feels that the permanent staff is generally comfortable with the use of the equipment; however, the temporary staff may not have been entirely comfortable using the MDCs or the magnetic swipe cards, especially early in the summer. CCRTA faces a number of barriers in properly training temporary summer drivers. Difficulties cited with training include unfamiliarity with computerized technologies, insufficient time for staff to train operators, and limited English language skills among operators who are from foreign countries.

5.9 Technological Issues

The dispatchers, operators, and management interviewed were each asked to rate the APTS components that they used for ease of use and reliability. The following components or functions were rated:

- AVL/GIS base station software (dispatchers and management);
- MDC for entering/tracking data (operators and management);
- MDC for sending and receiving messages (all users);
- Voice radio (all users); and
- Magnetic stripe cards (operators and management).

While the voice radio is not part of the APTS system, ratings were requested because the radio provides an alternative to communicating via the MDCs. Therefore, perceptions of the radio system could affect usage of the MDC system.

Dispatcher Assessments of Technology

In general, the dispatchers found the system easy to use, rating each feature good or excellent. As one dispatcher remarked, "The equipment is easy to use if you know what you are doing." With respect to reliability, the GIS base station was rated as good to excellent while communicating via the MDC was rated as good. The voice radio received mixed reviews for its reliability. This is due in part to a small number of "dead spots" within the CCRTA service area where signals cannot be sent or received. Parts of Woods Hole and Falmouth are affected by dead spots. Initially, dead spots affected MDC message transfer, although this problem has largely been solved by having the server store and re-send messages until they are successfully transmitted.

Another concern that some dispatchers expressed about voice radio reliability was related to the fact that only two radios are available for six dispatchers. (This change was introduced in fall 2000 by a new operations manager, to reduce voice radio traffic.) Three dispatchers found it disruptive to leave their workstations to send messages and confusing to figure out who is talking to whom, and felt that the reduced number of radios could on occasion result in queuing and congestion on the voice radios. On the other hand, two dispatchers preferred to rely on the MDC rather than the radio for communication and one noted that the switch had reduced noise and chaos in the operations center.

Dispatchers also reported problems with the paratransit scheduling system, noting that "a couple times each week," trips are canceled by the computer. (The cause of this reported problem was not clear.) If dispatch is unsure of the status of a trip, they must call the passenger back and ask them if they've canceled. While the scheduling software is distinct from the MDC communications equipment and software, this concern affects the dispatchers' willingness to rely exclusively on electronic versus hard copy development and distribution of trip manifests.

Another feature that the dispatchers rated was the silent alarm. Although the silent alarm works well, it has intentionally been used only twice since the installation of the system in 1998. They have had a significant number of false alarms, however, including some triggered by mechanics while working on the buses.

Operator Assessments of Technology

Overall the MDCs rated very high among operators for both ease of use and reliability, with most functions receiving either good or excellent assessments. Paratransit operators, however, rated the MDC only "fair" to "good" for sending messages, due primarily to the operators' ability to send only a limited number of messages electronically.

Operators did note that the magnetic stripe cards deployed in summer 2001 experienced a high failure rate when they were first introduced to the operators. As the pilot program progressed, however, the drivers became more familiar with the use of the cards, resulting in a higher rate of successful usage.

The operators also expressed some complaints about the characteristics of the MDCs. For example, reading messages can be difficult due to the small screen size, particularly during evening hours when it is dark outside. Operators suggested that if the screen were backlit, it might be easier to read. One operator noted that it is easy to hit keys by mistake; for example, the "passengers boarded" key is located next to the signoff key so it is easy to hit the wrong key while operating the vehicle. If the operator accidentally logs off, he or she must contact dispatch to be put back into the system. Another operator noted that shortcut keys are available (using the numeric keypad) that can help minimize this problem. However, another operator responded that he did not use shortcut keys because he did not remember which number was for which shortcut. In addition, when a message is sent, the MDCs beeps until that message is cleared. One of the operators stated that this feature is "aggravating."

Operators also noted occasional problems with data transmission or inability to use the MDCs. Some noted that they do not always receive messages that have been sent or that there is a time delay for the messages. In addition, operators reported occasionally becoming locked out of the system, requiring them to fall back on paper reporting. One source of these problems may be occasional dead spots where radio transmissions cannot be received, which could lead to delays in receiving messages. Also, lockups can occur if vehicle and operator assignments are not made correctly, or if operators forget to sign out the day prior, as the system requires that the vehicle identification match the route, tower, and server. Progress has been made towards minimizing these problems by providing additional training to operators, dispatchers, and administrators to ensure proper use of the system, and by adding software patches to fix glitches.

Some operators suggested that the mobile data computers should have greater flexibility in sending messages. The existing system is limited, offering operators the ability to send seven canned messages or a yes/no response. While operators indicated that they did not want to have to type in messages, a more extensive list of canned messages could cut down on the radio traffic. One way in which the operators felt the MDCs could be improved is by offering operators more message choices particularly for emergency situations such as mechanical emergency, ambulance, or police. Operators also suggested that a feature confirming receipt of a message by the dispatcher would encourage them to use the MDC more often.

Another feature that the paratransit operators cited as a potential improvement to the system is the ability to edit the trips on the MDCs. Sometimes when passengers are picked up they request a different drop-off then is on the manifest. If operators were able to edit the screen they could update the location for the record.

Management Assessments of Technology

CCRTA's Operations Manager also was asked to rate the ease of use and reliability of each of the components of the APTS system. His assessments of the components are similar to those of the fixed-route operators with the exception of two components. Each of the operators surveyed rated the ease of use of the radio system as excellent; however, the Operations Manager rated this component "fair." He felt the system would be improved if you could use the radio to talk to an individual driver without having to tie up the radio for the entire fleet. In addition he rated the magnetic stripe cards "good," which is higher than any of the drivers rated them, but noted concerns about the reliability and durability of the cards.

With respect to reliability, the Operations Manager rated all of the APTS components as either "excellent" or "good." Components that received less than excellent reliability ratings were those that were reliant on radio transmissions as well as the magnetic stripe cards. Because of dead spots in places like Woods Hole and Falmouth, radio transmissions could fail. He also noted that while he considers the silent alarm very reliable, there were a lot of false alarms.

CCRTA management and administrative staff reported that the Mentor/Tristar MDC system had some problems with reliability and software functionality when first installed in 2000 and 2001, but that these problems were mostly bugs associated with an "alpha" release of the system and they have been almost completely eliminated. Twenty software patches were required over the course of spring, summer, and fall 2001 to fix bugs and tailor the software to CCRTA needs. From a hardware perspective, on the initial batch of MDCs that were installed in the spring of 2001, the screens fell off when the temperature exceeded roughly 90 degrees Fahrenheit because of a problem with the glue. These screens were replaced under warranty by Mentor. Overall, management was pleased with the technical support provided by Mentor/Tristar for the AVL and MDC equipment, including on-site training and technical assistance as well fixing software and replacing hardware under warranty.

CCRTA management noted that particular strengths of the Mentor/Tristar system include the user interface, open systems architecture design in Visual Basic, documentation, and interface with X-Gate communications software. Management also noted a few weaknesses of the system, including limitations with GPS interface/longitude/latitude coordinates (e.g., paratransit trip latitude/longitude not recorded), and limited built-in query and reporting capabilities. More complicated reports require writing custom queries in Access/SQL. TriStar did not initially include a fixed-route report module with their software but CCRTA staff worked with the company to develop this product.

5.10 Management Assessment of Overall Benefits to CCRTA and its Customers

After interviews had been completed, both the CCRTA Assistant Administrator and the CATS Operations Manager were independently asked to complete forms ranking their perception of the various benefits of the APTS to CCRTA and to its customers. The goal was to obtain an assessment of 1) the level of benefit of each APTS impact, and 2) the relative importance of each benefit, to verify the qualitative findings obtained from the interviews. The results are shown in Table 5.10 (benefits to CCRTA) and Table 5.11 (benefits to the customer). It should be noted that while these two staff positions are in regular communication, they operate in different offices and may have differing perceptions or awareness of how the APTS is being used as well as its current and future capabilities.

With respect to benefits to CCRTA, both agreed that the most significant benefit was improved operations management, including oversight of operators and contractors and control of fixed-route operations. The Assistant Administrator also added a related benefit as "significant": improved response to transit service disruptions such as traffic congestion or a vehicle breakdown or emergency. These impacts share the common theme that CCRTA feels it is better able to ensure that its vehicles are in the right place at the right time to provide transit service as scheduled for the customer.

Aside from this item, there was not a clear agreement between the two positions on the relative importance of the remaining impacts. The Assistant Administrator felt that the communication, data management, and safety benefits were also significant while the benefits of additional data collection were moderate. In contrast, the Operations Manager felt that the data management and new data collection impacts were significant, while communication and safety impacts were moderate.

Table 5.10 Assessment of APTS Benefits to CCRTA

	Assistant Administrator		Operations Manager	
Impact	**Rank**	**Level of Benefit[1]**	**Rank**	**Level of Benefit**
Operations Management – Enhanced operations management, allowing better oversight of operators and contractors and control of fixed-route operations	1	Significant	1	Significant
Communication – Facilitating communication between dispatchers and operators	2	Significant	4	Moderate
Data Management – Reduced level of effort in terms of data entry, quality control, analysis, and reporting	4	Significant	2	Significant
New Data Collection – Collection of additional data to support operational planning	6	Moderate	3	Significant
Safety – Improved safety for vehicle operators	5	Significant	5	Moderate
Other – Improved response to transit service disruptions	3	Significant		

[1] Rated on the following scale: "significant benefit," "moderate benefit," "small benefit," "no effect," and "negative impact."

With respect to benefits to the CCRTA customer, there was also agreement on the most significant impact: improved information about the arrival time of buses. Again, however, there was some disagreement about the relative importance of other impacts. Notably, the Assistant Administrator felt that the benefits of the APTS for on-time performance were small, while the Operations Manager felt they were significant. Since operations staff cited few specific adjustments to improve on-time performance to date, this opinion may reflect the anticipation of future benefits through more extensive analysis of APTS data and through greater use of the system's capabilities for managing operations.

Table 5.11 Assessment of APTS Benefits to CCRTA Customers

	Assistant Administrator		Operations Manager	
Impact	**Rank**	**Level of Benefit**	**Rank**	**Level of Benefit**
Safety – Improved safety for passengers	3	Significant	5	Moderate
Paratransit Trip Scheduling – Greater ability to accommodate last-minute trip requests	4	Moderate	4	Moderate
Information – Improved information about the expected arrival times of buses	1	Significant	1	Significant
On-Time Performance (Fixed-Route) – Improved on-time performance	5	Small	2	Significant
On-Time Performance (Paratransit) – Improved on-time performance	6	Small	3	Significant
Other – Improved customer convenience (Advanced Travel Planner and last-minute paratransit trip adjustments)	2	Significant		

6.0 Summary of APTS Benefits and Costs

This section summarizes the benefits and costs of the APTS system in a number of different ways:

- By type of impact;
- According to the National ITS Program "few good measures";
- Compared with CCRTA's initial goals and objectives for the project; and
- For each of the APTS components individually.

6.1 Summary of APTS Benefits and Costs

Table 6.1 summarizes the various areas of impact of the APTS system according to the categories used in Section 5.0, the nature of the benefit or impact (identified by the National ITS program "a few good measures"), and available evidence on the impact. Table 6.1 also provides an assessment by the evaluation team of the relative magnitude of the *potential* impacts (once fully realized) as well as the *actual* impacts experienced to date. The magnitude of impacts is rated on a scale of "high," "medium," "low," or "none."

Table 6.1 Cape Cod APTS Benefits and Impacts

Impact Area	Use	Benefits/Impacts	Potential Impact[1]	To-Date Impact[2]	Evidence on Impacts
Operations Management					
Facilitate dispatcher-operator communications	Messages sent by MDC instead of voice radio	**Productivity:** Cuts down on voice radio traffic, allowing high-priority communication to occur Frees time for dispatchers to field customer calls more quickly Easier for dispatchers and operators to perform jobs	Med.	Med.	Anecdotally, improves operations and increases job satisfaction for **some** users Insufficient data to quantify benefits
Assist with on-time performance (fixed-route)	Has assisted CCRTA in controlling headways and moving toward fixed-headway system on summer trolleys	**Mobility:** Reduced wait time Less crowding	Med.	Low	No data available on pre-AVL on-time performance No quantifiable reductions in headway variation can be measured as a result of fixed-headway system
Reduce travel times (paratransit)	If linked with electronic routing/scheduling system, could potentially result in more efficient trip arrangements	**Mobility:** Reduced travel time	Low	None	No impacts observed

[1] Assessment by evaluation team of relative magnitude of *potential* benefits/impacts once fully realized.

[2] Assessment by evaluation team of relative magnitude of *actual* benefits/impacts experienced to date.

Table 6.1 Cape Cod APTS Benefits and Impacts (continued)

Impact Area	Use	Benefits/Impacts	Potential Impact[1]	To-Date Impact[2]	Evidence on Impacts
Add last-minute paratransit trips	AVL and PT software used to check location of buses and passenger load Paratransit trip adds/changes sent by MDC If linked with electronic routing/scheduling system, could potentially result in decreased advanced schedule time	**Mobility:** Potentially allows trips to be accommodated on shorter notice	High	Low	Estimated 3-5 trips/day added Has not facilitated more last-minute trips – just makes it easier to add/change trips
Identify improper operator behavior	Individual cases identified; disciplinary action taken	**Mobility:** Reduce missed stops **Productivity:** Reduce costs by reducing fraud and/or misuse of equipment	Med.	Med.	Cases of improper behavior identified roughly once a month One instance of repeated misuse by one contractor identified and contractor terminated
Silent alarm	Operator uses silent alarm to notify dispatch of incident	**Safety:** Operator can notify dispatch of incident even if not safe to do so using voice radio **Productivity (-):** False alarms take dispatchers' time	Med.[3]	Med.	Two cases of use in emergency situations (over two years of partial implementation and 1.5 of full implementation), one where driver was threatened with knife

[1] Assessment by evaluation team of relative magnitude of *potential* benefits/impacts once fully realized.

[2] Assessment by evaluation team of relative magnitude of *actual* benefits/impacts experienced to date.

[3] Low frequency of use, but potential value per use can be extremely high, especially if operator or passengers are at risk of injury.

Table 6.1 Cape Cod APTS Benefits and Impacts (continued)

Impact Area	Use	Benefits/Impacts	Potential Impact[1]	To-Date Impact[2]	Evidence on Impacts
Vehicle tracking	Dispatcher uses AVL to track vehicle with situation on-board and assist emergency response	**Safety:** Allows faster response to incidents including security problem, medical emergency, or vehicle breakdown	Med.	Med.	One or two situations/ summer Insufficient data to assess impacts on response time
Data Collection and Management					
Ridership and vehicle operating data entry	Electronic entry of pass. on/off; vehicle mileage, fuel, oil; and operator sign-on/ sign-off	**Productivity:** Less staff time required for data entry, QA/QC Makes operator's job easier	High	High	Est. total of one full-time admin staff position saved Time benefits to operators minor (a few minutes per day)
Data reporting	Ability to generate custom queries from database, e.g., vehicle miles, gas, oil by vehicle and month	**Productivity:** Less staff time in generating reports/queries Potentially quicker, more accurate information available to management and sponsoring agencies	Med.	Med.	Considered part of data entry time savings
Support service planning	Identify passenger boarding/ alighting locations, volumes, and times Reconfigure routes, schedules, and stops	**Efficiency, Mobility:** Reconfigure routes to serve high trip volume areas	High	Med.	Increase in ridership in one area coinciding with route reconfiguration enabled by APTS data analysis Could be greater potential with auto PT geocoding

[1] Assessment by evaluation team of relative magnitude of *potential* benefits/impacts once fully realized.

[2] Assessment by evaluation team of relative magnitude of *actual* benefits/impacts experienced to date.

Table 6.1 Cape Cod APTS Benefits and Impacts (continued)

Impact Area	Use	Benefits/Impacts	Potential Impact[1]	To-Date Impact[2]	Evidence on Impacts
Reduce travel times (fixed-route)	Has assisted CCRTA in identifying a route where schedule trip time could be reduced	**Mobility:** Reduced travel time	Low	Low	Decrease in scheduled route run time of 1 to 3 minutes (1.1 to 3.5 percent) on one route
Support marketing efforts	Identify residence area of passengers, location of visitation	**Efficiency, Mobility:** Target marketing efforts to increase ridership	High	?	Insufficient data
Audit contractor performance	Comparing MDC records of actual vs. contractor billed hours to identify fraud.	**Productivity:** Longer-term avoided costs (termination of poorly performing contractor)	High	High	Systematic violations by one contractor identified. Contractor terminated
Customer Information and Convenience					
Real-time bus location/arrival time	Dispatchers use map to estimate bus arrival time for passengers who call	**Mobility:** Estimated time of arrival	Med.	Med.	Real-time information requests about 30 times/ week during off-season (2/3 paratransit, 1/3 fixed-route). More during summer for fixed-route. Paratransit: Perhaps 4 to 6 times/month use AVL to check on customer complaint

[1] Assessment by evaluation team of relative magnitude of *potential* benefits/impacts once fully realized.

[2] Assessment by evaluation team of relative magnitude of *actual* benefits/impacts experienced to date.

Table 6.1 Cape Cod APTS Benefits and Impacts (continued)

Impact Area	Use	Benefits/Impacts	Potential Impact[1]	To-Date Impact[2]	Evidence on Impacts
Real-time bus location via web, kiosk maps	Customers can check location of buses on computer with Internet access or kiosk	**Mobility:** Reduced passenger waiting time	Med.	Low	Insufficient data
Magnetic stripe cards[3]	Free cards provided to visitors and hotel employees	**Mobility:** Free use of transit system **Efficiency:** Potential mode shift from auto to transit **Productivity (-):** Public subsidy required	High	Med.	Public subsidy cost equals monetary benefits to pass users Social benefit is primarily from reduced auto trips (insufficient data to quantify)
Transit Agency Costs and Time					
Capital costs and staff time		**Productivity (-):** Direct cost to transit agency	High	High	Roughly $1.08 million invested in development, design, and implementation plus up to $300,000 in value of staff time
Maintenance costs and staff time		**Productivity (-):** Direct cost to transit agency	Med.	Med.	$110,000 annual operations and maintenance costs, including staff time (2.0% of total operating budget)

[1] Assessment by evaluation team of relative magnitude of *potential* benefits/impacts once fully realized.

[2] Assessment by evaluation team of relative magnitude of *actual* benefits/impacts experienced to date.

[3] Phase 3 impact

6.2 A Few Good Measures

Table 6.2 summarizes findings regarding APTS impacts to date on each of the National ITS Program goals and "few good measures" identified in the evaluation plan.

The ITS "few good measures" represent end goals or outcomes of an ITS project that are related to the benefits, costs, and other impacts of transportation service provision to the general public. In contrast, many of the evaluation measures of importance to CCRTA are "means to the end." For example, improved communication and operations management are a means to achieving an improved quality of transit service for CCRTA's customers, or improved efficiency in the provision of this service.

The information available at the time of this evaluation was insufficient to provide a definitive and quantitative estimate of either the outcomes experienced to date from the project, or the expected long-term outcomes as expressed in the form of these measures. In part, this relates to the availability and quality of data: much of the data that could potentially be used to evaluate APTS benefits are collected by the APTS itself – but were not collected (or were not in usable format) prior to deployment of the APTS equipment. Also, implementation problems following full deployment in the summer of 2001 compromised the quality of data collected in the first few months immediately following this deployment.

The more fundamental problem with quantifying APTS benefits to date, however, is that many of the benefits of APTS are expected to be realized incrementally over time, rather than occurring immediately and simultaneously with deployment of the APTS equipment. Furthermore, the long-term benefits of the APTS will depend largely on what the transit agency does with the new data that are collected; how it uses the APTS to improve real-time operations; and how the information collected by the APTS is made available to the customer. In addition, staff involved with the deployment of the project feel that its full benefits will not be realized until all of the components are in place – including full utilization of electronic fare media. The benefits of the entire APTS system may be greater than the sum of the benefits of its parts.

Table 6.2 A Few Good Measures

Goal Area	National ITS "Few Good Measures"	Surrogate or Alternative Measures	Hypotheses	Observed Impacts[1]
Safety	• Reduction in crash rates	• Reduction in incident response time	• Incident response time will decrease as the ability of CCRTA to locate its vehicles is improved	• Increased perception of safety by vehicle operators • Incidents and use of alarm too infrequent to quantify impacts
Mobility	• Reduction in delay • Reduction in travel time variability • Improvement in customer satisfaction	• Average travel time or speed per trip • Advance time required to schedule trip • Schedule adherence • Provision of customer information • Customers/trips served • Customer satisfaction	• Scheduling/routing efficiency will increase, thus: – Reducing trip times – Allowing trips to be scheduled with less advance notice – Decreasing the size of the pick-up window • More customers can be served (for a given cost) as a result of increased operating efficiencies • Customer satisfaction will improve as a result of improved performance and information	• Real-time information on bus arrival times more readily available via telephone and Internet • No significant changes (on a systemwide level) to: – Trip times – Customers/trip – On-time performance – Size of the pick-up window – Advance scheduling time • New data facilitated route restructuring in one area, apparently increasing ridership (but unknown impacts on travel time and convenience)
Efficiency	• Increases in throughput or effective capacity • Congestion relief	• Passenger trips per vehicle hour • Number of trips shifted to fixed-route transit	• Improved operating efficiencies will increase transit system throughput/capacity • Because of better information, some trips or trip segments can be shifted to fixed-route transit, thus improving systemwide capacity	• No efficiency impacts measured to-date • Insufficient data to assess whether ridership has increased because of better provision of customer information

Table 6.2 A Few Good Measures (continued)

Goal Area	National ITS "Few Good Measures"	Surrogate or Alternative Measures	Hypotheses	Observed Impacts[1]
Productivity	• Cost savings • Job satisfaction	• Staff time per task (calls, scheduling, maintenance, etc.) • Cost per passenger-trip or passenger-mile • Cost per vehicle-hour • Staff acceptance	• Through more effective scheduling, dispatching, and fleet control, the overall staff time requirements and hence cost per unit of service provided will decrease • The APTS technologies will be viewed as beneficial by transit agency staff in assisting them with their jobs	• Minor benefits with respect to time savings for specific tasks for dispatchers and operators • One full-time data entry position eliminated • One full-time information technology position created • Significant up-front investment of staff time in developing and deploying system • No impacts observed to-date on cost per vehicle-hour • Improved job satisfaction for dispatchers and operators

[1] Impacts for Phase 1 and 2 only.

6.3 Achievement of CCRTA Goals and Objectives

It is also helpful to compare the findings of this evaluation according to each of the goals and objectives described by CCRTA at the beginning of the project. As noted, some of these are end goals (e.g., reducing the cost per passenger trip) while others are means to the end (e.g., improving dispatching operations). Table 6.3 presents the CCRTA goals and objectives as described in the evaluation plan, along with an assessment of the extent to which these goals and objectives have been met.

Table 6.3 Achievement of CCRTA Goals and Objectives

CCRTA Goal	Has Project Met Goal?
Improving dispatching operations.	Yes. Benefits include: holding buses or deploying additional buses to help maintain schedule under congested conditions; taking remedial/disciplinary action against operators intentionally deviating from route or schedule; providing more accurate information to customers; and facilitating communications with vehicle operators.
Reducing the cost per passenger trip.	Not yet demonstrated. This benefit relies primarily on long-term service adjustments and fare incentives to switch passengers from paratransit to fixed-route. This is an intended outcome of Phase 3.
Showing that ITS can work for rural transit operations.	To some extent. The project has demonstrated the successful implementation of ITS for rural transit, from an operational perspective, and is demonstrating ways in which it is valuable. The project has not yet demonstrated the cost-effectiveness or financial viability of ITS for rural transit operators.
Providing better passenger information.	To some extent. The system is making real-time information available to passengers via telephone and Internet media. However, the access to or utility of this information to all of CCRTA customer segments has not been fully developed. Expansion of information and information media in the future is likely to result in greater benefits.
Promoting open, interoperable systems in ITS.	Yes. Project sponsors were able to successfully identify and implement open-systems architecture for all components.
Enhancing the amount and quality of the data available for planning and analysis.	To a large extent. The system's capabilities for gathering and archiving data have been successfully demonstrated, and the data have been used in a handful of cases to support planning. Improved attention to data quality in the future will fully demonstrate the attainment of this goal.
Improving safety and security for transit operators and customers.	Yes. Even though there have been few instances in which the silent alarm and the AVL system have been used in threatening situations, nevertheless provide what operators, dispatchers, and management view as an important enhancement in case a serious incident should occur.

6.4 Benefits by APTS Component

Not all of the APTS components demonstrated in the Cape Cod APTS project must be implemented simultaneously. It is of interest to describe which components could be implemented separately, and what are the benefits of individual components compared to the system as a whole.

A **communications infrastructure and local area network** are both required components to make use of most of the other APTS functions. Conducting data communications over the existing voice radio network was shown to be infeasible for CCRTA operations. AVL data might be collected and archived on a central server without a local area network, but it could not be distributed to dispatchers on a real-time basis or accessed by more than one user at a time.

The **AVL and GIS mapping software** could be used independent of the MDCs to track vehicles for real-time operations control as well as data collection and archiving. (The AVL could be used by itself – without mapping software – for data archiving, but the ability to make use of this data would be greatly reduced.) If the AVL/mapping capability was implemented without the MDCs (as was the case during Phase 1), it could be used by dispatchers for real-time control of operations via voice radio, and it would still collect some data for historical evaluation of factors including on-time performance, operator behavior, and vehicle-miles/hours of travel. Without the MDCs, however, the system could not collect data on passenger boardings/alightings by location, driver sign-on/sign-off, mileage, fuel, or oil.

The **MDC,** on its own, could be used to facilitate communication with the operations center, transmit manifests, and record items such as times of operator log-on and passenger boardings. However, without the spatial data provided by the AVL, the value of the data collected would be greatly reduced. The silent alarm feature would be available to notify dispatchers of an emergency, but would be nearly worthless because dispatchers would be unable to pinpoint the operator's location without voice radio contact.

Electronic fare payment systems require the MDC and supporting communications infrastructure to be present, but would greatly benefit from the additional, spatial data provided by the AVL (for example, to allow distance-based fare pricing and to record locations of boardings/alightings).

Internet-based customer information requires the hardware and software capability to host an Internet site. The Internet can be used to distribute customer information to people via their home or workplace computers, as well as via kiosks in hotels, transit centers, or other major tourist destinations. In the future, it will also allow real-time information to be transmitted by cellular telephone as well as personal digital assistant, although these capabilities have not yet been demonstrated on the Cape. The value of these customer information capabilities depends not only on the value of such information to the customer, but also on access of the customer to the various media at the appropriate time.

These advanced technology alternatives appear most likely to be used by tourists on the Cape. Given the high percentage of Cape transit users who are elderly, it is possible that many do not have access to a computer to provide real-time information. However, by using a telephone, they can obtain the same information by calling the operations center.

7.0 Lessons Learned

The interviews conducted for this evaluation suggest a number of "lessons learned" with respect to the deployment of APTS technology in a rural transit environment:

- **Infrastructure needs to be in place** to support the AVL and MDC. Infrastructure requirements include a fast and reliable local area network at the operations center; a redundant set of servers with expansive data storage capacity; and a data radio system separate from the existing voice radio system. Infrastructure design, development, and installation represents a significant cost of APTS deployment. However, CCRTA felt it was important to invest up front in a thoroughly designed system that could take maximum advantage of the APTS capabilities and minimizing problems during implementation and use.

- **Proceed incrementally** to the extent possible. CCRTA's trial deployment of 20 AVL units demonstrated limitations to their initial choice of technology. The agency determined that a different in-vehicle product would be cheaper, more responsive to their needs, and have a broader range of capabilities. Similarly, they were able to use a zero-capital communications technology for this initial demonstration, but also determined that a communications technology with higher initial investment and lower operating cost would be preferable in the long term. If a similar system has not previously been installed by the vendor, a small-scale test is recommended to ensure that the technology functions well.

- **A strong commitment from the transit agency, as well as an investment in knowledge base, is required** to successfully deploy APTS. According to the CCRTA Assistant Administrator, "The user interface is simple, but underneath is a very complex and sophisticated technology. If it is not managed properly, it won't work." In CCRTA's case, having a technologically savvy project manager from a local university was very helpful to the project. CCRTA administrative, operations, and maintenance staff also made significant time commitments to the design, development, and deployment of the APTS. The transit agency must also commit over the long term to information technology support in order to maintain the system and ensure use of its full capabilities.

- **A commitment to data integrity is critical.** Much (perhaps most) of the benefit of the APTS system is due to its ability to collect and maintain data to benefit system operations and planning. For example, if vehicle operators fail to log in or mis-enter boardings data, the benefits of the system will be compromised. Vehicle operators as well as other users of the system must be trained in the proper use of the system for data collection, and data quality must be monitored.

- **Start-up bugs may be expected**, especially with new and untested technology. The MDC and software implemented by CCRTA were an "alpha-release" by the manufacturer, which had not previously implemented a product for use on both paratransit and fixed-route vehicles simultaneously. As a result, numerous software patches were required both to fix bugs and also to customize the system to CCRTA's needs. A design flaw also led to the replacement of a batch of MDCs under warranty. As manufacturers gain more experience with the design and implementation of APTS systems, such start-up glitches are likely to decrease dramatically.

- **Vehicle operators can be convinced that the APTS system benefits them**. Some transit agencies deploying AVL have run into difficulties with vehicle operators viewing the system as a "big brother." Neither management nor operators interviewed at CCRTA viewed this as a problem. For the most part, operators instead tended to view the system as a benefit since it was used to resolve customer complaints usually in the operators' favor.

- **The benefits of an integrated system are likely to be greater than the sum of the benefits of individual components.** One of CCRTA's primary objectives for the project was to shift customers from paratransit to fixed-route services through more effective fixed-route service provision and structured fare incentives using electronic payment systems. This objective has not yet been realized, largely because EPS demonstration is in the early stages and CCRTA is just beginning to make use of the data provided by the APTS. CCRTA's objective of increasing ridership through improved customer information is also taking time to materialize. The basic information infrastructure must be in place and proven before it can be extended to the full range of information media.

- **To maximize the value of the APTS, the transit agency must have a long-term vision for the APTS system** and a commitment to follow through with the vision. The agency must be willing to continually "think outside the box" and innovate its services. The primary value of the APTS may not be to help the agency continue to provide service the way it has always been provided, but rather to provide new data that can be used to achieve service innovations such as route restructuring, integrated fare payment systems, and real-time customer information. Making use of the data – rather than simply collecting the data – is the key to unlocking the benefits of APTS.

- **Many of the benefits of APTS may not be realized right away, but may accrue over time.** As system components are integrated, operations refined, and service changes implemented, it is hoped that these innovations will ultimately increase productivity, ridership, and quality of service.

Appendix A

List of Acronyms

List of Acronyms

APTS	Advanced Public Transportation System
ATP	Advanced Travel Planner
AVL	Automatic Vehicle Location
CATS	Cape Area Transit Systems, Inc.
CCRTA	Cape Cod Regional Transit Authority
CCTTP	Cape Cod Transit Tourist Pass
CDPD	Cellular Digital Packet Data
CIS	Customer Information Systems
CMAQ	Congestion Mitigation and Air Quality
DSS	Decision Support Service
EPS	Electronic Payment Systems
ETA	Estimated Time of Arrival
FFY	Federal Fiscal Year
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GATRA	Greater Attleboro-Taunton Regional Transit Authority
GIS	Geographic Information System
GPS	Global Positioning System
HSA	Human Service Agency
HST	Human Services Transportation
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
LAN	Local Area Network
MDC	Mobile Data Computer
P&B	Plymouth and Brockton Street Railway Company
PC	Personal Computer
SBIR	Small Business Innovative Research
SFY	State Fiscal Year
SQL	Special Query Language

Appendix B

Transit Tourist Pass Survey Results

Transit Tourist Pass Survey Results

This appendix describes the methodology and results of a survey of users of the Cape Cod Transit Tourist Pass (CCTTP) conducted in August 2002. The purpose of the survey was to determine how the provision of the free passes on the shuttle services has affected travel mode choice while on the Cape. The findings were also used to infer the vehicle-trip reduction and emissions benefits of the pass program as well as increases in CCRTA transit ridership.

The provision of a free pass (as compared to the standard cash fare) through the CCTTP program does not, by itself, appear to have had a significant impact on peoples' decision to use the CCRTA shuttle service. However, the availability of the shuttle service (regardless of the fare payment mechanism) appears to have helped to reduce vehicle-travel – especially in the Provincetown area – and has provided a mobility benefit to both Cape visitors and hotel staff. In addition, the CCTTP program appears to have had a significant benefit in helping to publicize the transit service to visitors, and therefore can be credited with helping to reduce vehicle-travel and emissions.

■ Pass Program Overview

As part of the Cape Cod APTS program, CCRTA developed a demonstration project for electronic payment systems known as the Cape Cod Transit Tourist Pass (CCTTP). The CCTTP program was funded by a two-year Congestion Mitigation and Air Quality (CMAQ) grant to provide user-side subsidies using electronic payment systems to promote increased use of transit on the Cape.

The CCTTP demonstration program was initiated in summer 2001 in cooperation with the Cape Cod Chamber of Commerce, and was expanded during the summer of 2002, the second year of the CMAQ grant. Under the program, hoteliers located within one-quarter mile of a CCRTA fixed route with Internet capabilities were recruited to participate in a demonstration of electronic fare media. Participating hotels received free passes to distribute to their guests to encourage transit use during their visit to Cape Cod. Each participating hotel was required to enter a minimal amount of information for each guest receiving a pass. In return for their effort, the hotels were also allowed to provide the passes to their employees.

During summer 2001, pass users were required to give their pass to the vehicle operator upon boarding and alighting so that he or she could insert it into the card reader in the MDC terminal head. Because this arrangement was awkward and time-consuming, for summer 2002 CCRTA installed remote pass readers on the right-hand side of the dashboard of vehicles, so that passengers could swipe the card themselves upon boarding. Passengers were not requested to swipe their card upon alighting. The boarding time and location is recorded electronically by the Mobile Data Computer (MDC) and transmitted to the MDC database at CCRTA operations center. Each pass has a unique ID, which can be associated with data on the pass user entered by the hotel distributing the pass.

Potential Benefits of the CCTTP Program

The benefits of the Cape Cod summer shuttle transit service in general, and the CCTTP program in particular, may include:

- **Mobility –** Increased travel options for Cape visitors, hotel staff, and residents;
- **Vehicle Travel-Reduction –** A reduction in vehicle-trips and vehicle-miles of travel, leading to reduced congestion and parking problems, especially in village centers; and
- **Air Quality –** Reduced emissions, leading to improved air quality.

In this evaluation, the additional benefits of the CCTTP program need to be distinguished from the benefits of the summer shuttle transit service without the CCTTP program. The CCTTP program could help to increase transit ridership (by tourists and hotel staff) for two reasons:

- **Reduced Cost –** Under the pass demonstration program, a transit trip is free, rather than $1.00 for adults or $0.50 for children and senior citizens. For a family of four making a two-way trip, this represents a cost savings of $6.00.
- **Improved Awareness of the Shuttle Service –** CCRTA has placed an emphasis on marketing the CCTTP program as well as the shuttle service to area hotels, who in turn may provide information on the service to their guests.

User Survey Methodology

Data on the total number of pass users on the Cape Cod system, including by route, boarding location, date, and time, can be readily obtained from the MDC database which automatically records pass usage. To estimate other benefits of the pass program, such as vehicle trip-reduction, additional information is required about the users of the passes. To obtain this information, a one-page survey form was developed, designed to be administered on-board the CCRTA transit routes. The survey asks questions about whether the person traveling had a vehicle available for their use, how they would have traveled if they did not have the pass, and how they learned about the pass. The survey instrument is shown in Appendix C.

To minimize data collection costs and maximize the number of survey responses, the survey was administered only on the Provincetown Shuttle. The Shuttle shows by far the highest pass ridership on the CCRTA system, carrying approximately 85 percent of all pass trips during summer 2001 and 93 percent of all pass trips during summer 2002 (based on data through September 2, 2002). Therefore, most of the benefits of the program are realized from the Provincetown service. The high ridership on the Provincetown Shuttle can be attributed to two primary factors. First, the central area of Provincetown – a major tourist destination – experiences high levels of traffic congestion and a general shortage of parking (parking is priced at up to $10.00 a day and central lots often fill before noon). Also, this part of town is compact and walkable, so a car is not necessary. Second, high-speed ferry service from Boston provides an attractive alternative to driving (the ferry trip is 90 minutes, compared to a two and one-half to three hour drive). Many visitors from the greater Boston area choose either to leave their car at home, or (especially if they live in Boston) do not have a car. Intercity bus service (three and one-half to four hours from South Station in Boston) and air service (charter only) also provide alternative travel options.

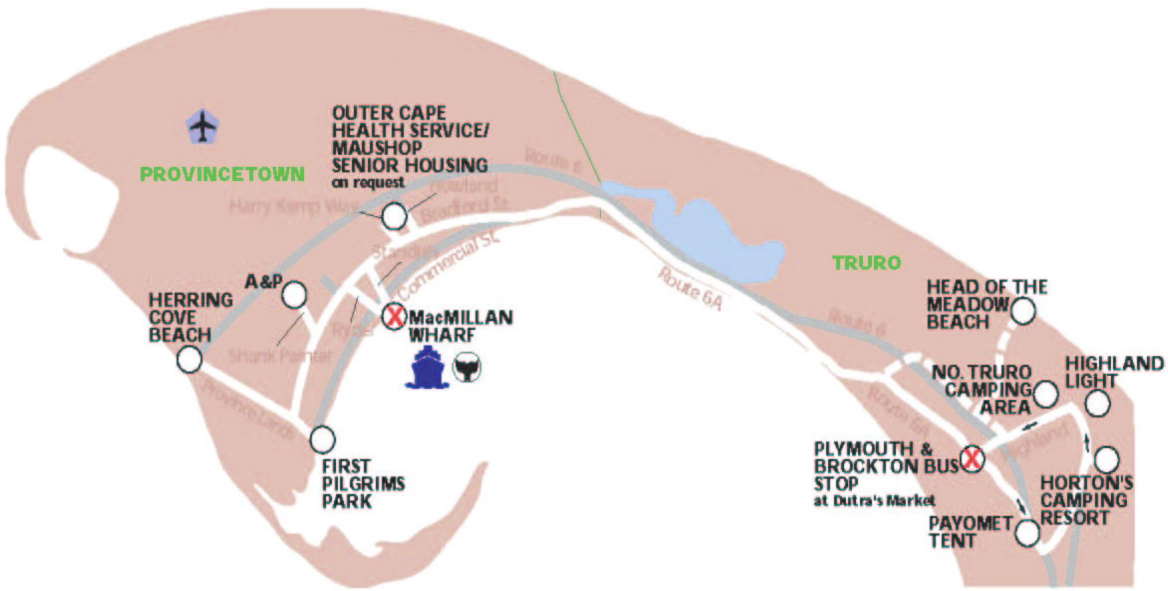
Surveys were administered on two days: Friday, August 23 and Friday, August 30, 2002. These days were selected because it was assumed that the riders would represent a mix of weekday and weekend visitors to the Cape.[1] August 30 was the Friday before Labor Day weekend. After Labor Day, service levels, ridership, and pass usage drop off sharply, so August 30 was deemed to be the final opportunity for data collection. Pre-testing was conducted on August 23, and since the results of the pre-test were successful (only minimal changes were made to the final survey instrument), they were integrated with the August 30 survey results.

Surveys were administered from 11:00 a.m. to 6:00 p.m. by a crew of four Cambridge Systematics staff, who received advance training. The Provincetown Shuttle runs in two separate loops, which connect at a layover point at MacMillan Wharf in Provincetown (Figure B.1). Two surveyors rode the Herring Cove loop, which has two vehicles running at 20-minute headways from the Wharf in Provincetown to Herring Cove Beach, serving hotels and local businesses along the route. The other two rode the North Truro loop, which serves hotels and resorts along Route 6A, along with two campgrounds at the end of its route in Truro. This loop has three vehicles running at 20-minute headways. While surveyors only covered two of every three vehicles, it was assumed that coverage throughout the day would ensure that most visitors would receive the opportunity to complete a survey at least once (since they were likely to ride more than once). By the end of the survey period it did, indeed, turn out that most pass users had already completed a survey.

---

[1] Although one might expect weekend usage to be higher, the MDC data show that pass usage actually remained nearly constant throughout the week. The average number of pass trips taken per day during July and August 2002 ranged from a low of 422 on Mondays to a high of 525 on Fridays.

Figure B.1 CCRTA Provincetown Shuttle Routes, Summer 2002



Source: Cape Cod Regional Transit Authority.

Pass users (especially visitors) tend to board and alight at only a few locations: MacMillan Wharf (both loops), Herring Cove Beach and the Provincetown Inn on the Herring Cove loop, and the Cape Inn and Sandcastle Inn on the North Truro loop. These three hotels have promoted the pass most heavily and were collectively responsible for 76 percent of the passes issued and 62 percent of trips taken in summer 2002. Other, scattered pass ridership originates at hotels, guesthouses, and campgrounds along the two loops. The origins and destinations of hotel staff are somewhat more dispersed than those of visitors.

After boarding the bus, people using passes were asked to complete a survey. For visitors traveling in groups, only one person in the group was requested to complete the survey. Hotel staff were each asked to complete a survey individually, rather than being treated as parties.[2] In total, 79 usable surveys, representing 143 traveling people, were collected. Of these surveys, 38 were collected from visitor parties, 35 from hotel staff/workers, and the

[2] This decision was made after the pre-test, because some hotel staff boarding together got off at different locations, and because the survey staff realized that hotel staff likely came to the Cape individually and therefore may have answered the survey questions differently even if they were traveling together at the time of the survey. In the pre-test, four surveys of hotel staff were given to only one member of a group of two or more; in the final analysis, these surveys were treated as individual responses.

rest (six) from people who identified themselves as residents or did not answer this question. The survey response rate was quite high, with only a handful of people refusing or unable to complete the survey.

The number of surveys collected was somewhat lower than anticipated, based on estimates from the pre-test. The weather was rather poor on the pre-test date (cloudy and cool), nearly eliminating traffic to the beach (although many people may have chosen to travel into town instead), so it was hoped that the weather would be better on the survey date. In fact, though, the weather was similarly cloudy and cool on the survey date. It was also hoped that ridership would be higher because of the proximity to Labor Day weekend. Retrospective data, however, show that pass usage was actually higher than average on August 23 (609 systemwide trips) and slightly lower than average on August 30 (460 systemwide trips). August 30 may in fact have been a high-turnover day, with many people leaving and arriving at the Cape (and therefore not using the shuttle). Also, because the same people usually rode the shuttle for more than one trip, four surveyors could not collect four times the number of surveys that one surveyor could.

Despite the smaller-than-expected sample size, the number of surveys collected is sufficient to draw some general conclusions about the benefits of the program. The sample size yields a 95 percent confidence interval of approximately +/- 16 percent for both the visitor party and hotel staff populations.

■ Survey Findings

The surveys displayed a fairly even split between visitors and hotel workers, with 48 percent of the responses collected from visitor parties and 44 percent collected from hotel staff/workers (Table B.1). The remaining eight percent of survey respondents either identified themselves as residents of the Cape (four) or did not complete this question (two). Because there were multiple people in some visitor parties, visitors represented 67 percent of survey respondents (Table B.1). Overall, the party size for visitors ranged from one to six with an average party size of 2.53 passengers (Table B.2).

The split of visitors versus hotel staff during the survey period appears lower than normal, since according to card data from summer 2002, 84 percent of trips on the Provincetown Shuttle were by hotel guests (visitors). While passes are only supposed to be distributed to hotel guests and staff, it appears that a small number of them found their way into the hands of residents.[3] Survey results are not reported for "residents" or non-respondents to Question 2 because of the small sample size, and because of the importance of differentiating travel behavior by type of respondent.

[3] To be technically correct, "non-staff residents" might be a better term, since hotel staff could be considered residents. In fact, though, many of the hotel staff (and probably most of those using the shuttle buses) are actually temporary workers rather than permanent Cape residents.

Table B.1 Question 1 – Are You a:

	Number of Responses	Percentage of Responses	Number of People Represented	Percentage of People Represented
Visitor Parties	38	48%	96	67%
Hotel Staff/Worker	35	44%	35	24%
Other[a]	6	8%	12	8%
Total	**79**	**100%**	**143**	**100%**

[a] **Note:** Four respondents specified "resident"; two did not answer.

Table B.2 Question 2 – How Many People Are Traveling in Your Party on This Bus (Including You)?

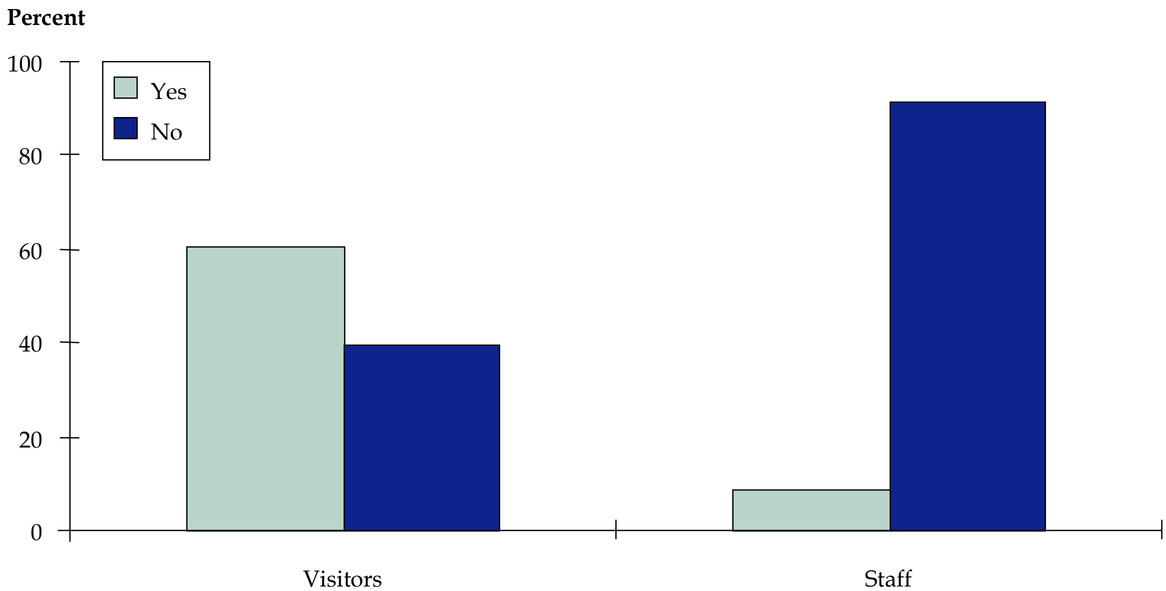
	1		2		3		4		5		6			
	#	%	#	%	#	%	#	%	#	%	#	%	Average	Median
Visitor	6	16%	19	50%	5	13%	5	13%	1	3%	2	5%	2.53	2

Pass carriers were asked whether they or anyone in their party had a car/private vehicle available on the Cape with which they could have made their trip. Sixty-one percent of visitor parties (23 of 38) but only nine percent of the hotel workers (three of 35) reported that they had access to a car. Figure B.2 and Table B.3 show vehicle availability by passenger type.

Table B.3 Question 3 – Did You or Anyone in Your Party Have a Car/Private Vehicle Available on the Cape That You Could Have Made This Trip with?

	Yes		No	
	#	%	#	%
Visitor Parties	23	61%	15	39%
Hotel Staff	3	9%	32	91%

Figure B.2 Vehicle Availability by Type of Respondent

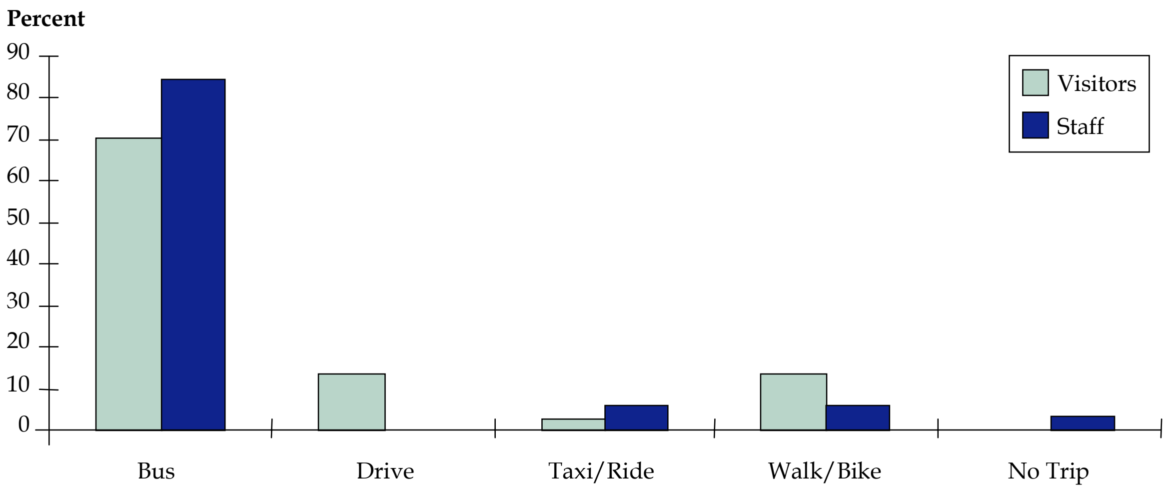


The next question on the survey asked how the pass user would have made this particular trip if they did not have a free pass. Most respondents, both visitors and hotel staff, indicated that they would have taken the shuttle anyway but would have paid the $1.00 fare. Comparing alternative travel modes by type of respondent, 70 percent of visitor parties and 85 percent of hotel staff indicated they would have taken the bus even if they had to pay the fare. For visitors, driving and walking/bicycling each accounted for an additional 14 percent of the responses (five responses for each mode). Four of the hotel staff surveyed (12 percent) would have taken a taxi, gotten a ride, walked, or bicycled. Figure B.3 and Table B.4 show alternative travel choice mode if the free passes were unavailable.

Table B.4 Question 4 – If You Did Not Have the Free Transit Tourist Pass, How Would You/Your Party Have Made This Trip?

	Bus		Drive		Ride/Taxi		Walk/Bike		No Trip	
	#	%	#	%	#	%	#	%	#	%
Visitor Parties	26	70%	5	14%	1	3%	5	14%	0	0%
Hotel Staff	28	85%	0	0%	2	6%	2	6%	1	3%

Figure B.3 Alternative Travel Choice if Free Pass were Unavailable

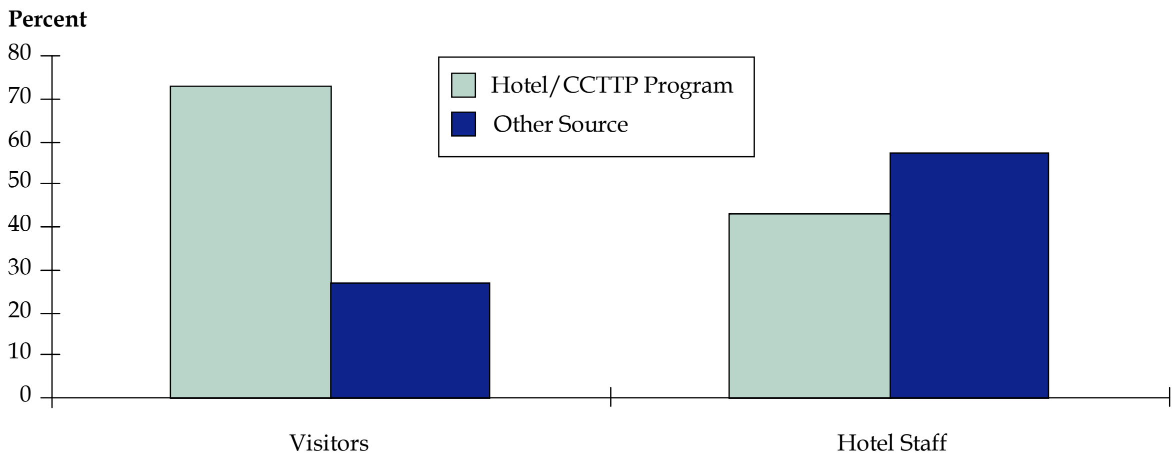


Pass users were also asked about whether they first learned about the CCRTA bus service because their hotel was providing the CCTTP pass (Figure B.4 and Table B.5). The objective of this question was to determine the extent to which the CCTTP program helped market the transit service to visitors. Over 70 percent of visitors first learned about the bus through their hotel. Workers were much more likely to have known about the bus service in advance, with only 43 percent noting that they first learned about the service through the CCTTP program. According to CCRTA, availability of the shuttle and housing assistance are recruitment incentives that businesses use to encourage guest workers to come to work on the Cape.

Table B.5 Question 5 – Did You First Learn about This Bus Service Because Your Hotel Was Providing a Tourist Transit Pass?

	Yes		No	
	#	%	#	%
Visitor Parties	27	73%	10	27%
Hotel Staff	15	43%	20	57%

Figure B.4 Original Source of Information About CCRTA Bus Service



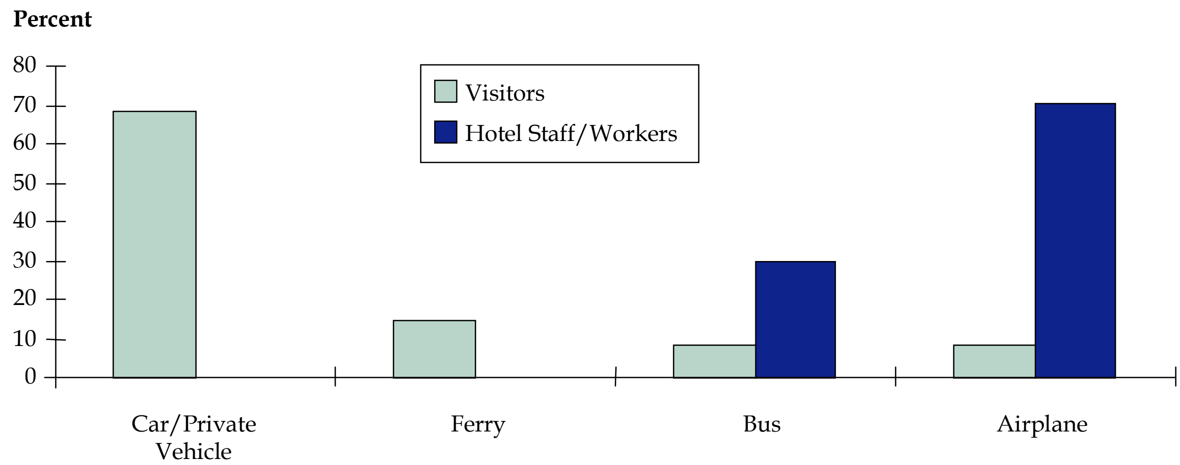
Pass holders were also asked about travel modes used to access the Cape (Figure B.5 and Table B.6). A variety of modes were used to access the Cape, and depending on the type of pass user, visitor, or hotel staff/worker, the results varied significantly. Most visitors surveyed (nearly 70 percent) accessed it by car. However, many of the hotel staff/workers interviewed were foreign workers who were working temporarily on the J-1 visa exchange program and therefore accessed the Cape by either airplane and bus (it is probable that many of the hotel staff answering "airplane" actually flew into a major airport off the Cape and then took ground transportation to the Cape). There were no hotel workers surveyed who used a private vehicle to access the Cape.

Table B.6 Question 6 – Now Think about Your Trip to the Cape. How Did You Get Here?

	Car/Private Vehicle		Ferry		Bus		Airplane		Other or Multiple[a]
	#	%	#	%	#	%	#	%	
Visitor Parties	24	69%	5	14%	3	9%	3	9%	3
Hotel Staff	0	0%	0	0%	10	29%	24	71%	1

[a] **Note:** Not included in percentages.

Figure B.5 Mode of Access to the Cape



Respondents also were asked whether they could have taken a car to the Cape, and whether the availability of the shuttle service influenced their decision not to bring one. Thirty-eight percent of visitor parties to the Cape who did not arrive by car (five of 13) reported that they had access to a car which they could have used to make the trip to the Cape (Table B.7). For hotel staff, this percentage was only six percent (two of 32).

For those persons who had access to a car but chose not to bring it, the availability of the shuttle did not appear to be a significant factor in the decision-making process, although the sample size is too small to draw any definite conclusions on this point. One visitor party said the availability of the shuttle "somewhat" influenced their decision, two said it did not, and two said they were not aware of the service (Table B.8). Table B.9 shows the responses to Question 8 of everyone who did not have a car available on the Cape, whether they answered "yes" or "no" to Question 7. The interpretation of this table is somewhat ambiguous because people who did not own a car would not have had the option of bringing their own vehicle, but nevertheless could have considered renting a car as an option. The survey was not designed in a manner that can distinguish the impact of shuttle service availability on the decision to rent a car. Table B.9 illustrates, though, that a number of people were not aware of the shuttle service before coming to the Cape.

Eight-six percent of visitor parties (12 of 14) and 89 percent of hotel staff (24 of 27) indicated that they either did not know the bus existed or that they would not have brought a car down anyway (Table B.8). Only two visitors and three hotel staff indicated that the availability of the bus had at least some influence over their decision not to bring a car to the Cape.

Table B.7 Question 7 – If You Did Not Come by Car/Private Vehicle, Do You (or Anyone in Your Group You Came with) Own a Vehicle That You Could Have Driven to the Cape for This Visit?

	Yes		No	
	#	%	#	%
Visitor Parties	5	38%	8	62%
Hotel Staff	2	6%	30	94%

Table B.8 Question 8 – If You Chose Not to Bring a Car, Did the Availability of This Bus Service Influence Your Decision? (Only Respondents Answering Yes to Question 7)

	Definitely		Somewhat		No		Did Not Know Service Existed	
	#	%	#	%	#	%	#	%
Visitor Parties	0	0%	1	20%	2	40%	2	40%
Hotel Staff	0	0%	0	0%	1	50%	1	50%

Table B.9 Question 8 – If You Chose Not to Bring a Car, Did the Availability of This Bus Service Influence Your Decision? (All Respondents without a Car)

	Definitely		Somewhat		No		Did Not Know Service Existed	
	#	%	#	%	#	%	#	%
Visitor Parties	1	7%	1	7%	7	50%	5	36%
Hotel Staff	1	4%	2	7%	11	41%	13	48%

Survey respondents were also given an opportunity to provide written comments about the survey (these comments are presented in full in Table B.10). The overwhelming majority of comments received were positive. In general, people were very appreciative of the shuttles, giving them high marks for service and convenience. Several hotel staff cited the difficulties of getting around if the shuttle were not available, particularly due to the rural characteristics of the Cape. Visitors to the Cape also rated the service highly; one typical comment praised the convenience of the service and the advantages of not having to worry about parking.

Table B.10 Cape Cod Transit Tourist Pass User Survey Comments

- A very practical and convenient way of traveling into town. Especially like the part of not having to worry about parking. Plus now can spend more in the stores. Thank you. One complaint – wheelchair/handicap buses should be available or if they are more so. (Visitor)
- We really appreciate the bus service and the tourist pass! It's a lot easier than riding our bikes into town every day. (Visitor)
- They should make it $0.50 for residents because we take it so often. I get the cards because many of my friends own hotels. (Resident)
- Having worked in North Truro since June 21st the bus service has been invaluable. I have come to this area from England and the bus enables me to get to town and the pass has saved me a significant amount of money allowing myself and my colleagues to go to town without planning. It has also provided access to facilities e.g., library that wouldn't perhaps have been as easy! (Staff)
- Great service, could not have survived in the rural location in which I worked without it! (Staff)
- The bus system is very convenient, because it travels the routes that I want to go to. It is here when you need it and you don't have to worry about calling a cab. They take such a long time to get where you are and most of the time they don't come anyway. This is a very good decision to have this bus system and the card system you just swipe and go. I wish the bus would run a little bit later than scheduled. Hope to see this system again next year. (Staff)
- Thank you a lot! (Staff)
- I think this shuttle service is absolutely vital to the employees that work on the Cape. I came to America on the J-1 visa exchange program so I relied heavily on the shuttle with regards to getting to the supermarket for food etc. Without it I feel that it would have been too expensive for me to live here for the summer period, as North Truro is quite rural. Also I would like to compliment the bus drivers. I have seen how hard they worked this summer and they were all extremely helpful and friendly to all customers. I also think the free bus passes were amazing since I was working for the hospitality industry it was very rewarding getting free transport. (Staff)
- A definite must for following seasons. Cheers. (Staff)
- This service is really good. My friends and I get around anytime we want convenient to us. (Staff)
- Need to go to the inn before going to the beach. (Staff)

Vehicle-Trip Reduction and Air Quality Benefits

The goals of the CMAQ program, which funded the CCTTP demonstration project, are to reduce traffic congestion and improve air quality. The CMAQ program requires reporting of estimated benefits from funded projects in terms of tons of pollution reduced. Based on the survey data, some approximate estimates of reductions in vehicle-trips, VMT, and tailpipe emissions can be generated. These estimates are not precise, but nonetheless provide a picture of the magnitude of benefits realized. These measures of benefit do not reflect other benefits of the CCTTP program, such as enhanced mobility for visitors and hotel staff.

Because of the small number of hotel staff pass users having cars available, vehicle trip-reduction benefits were estimated only for visitors. Two estimates of benefits were made. The first, more conservative estimate assumes vehicle trip-reduction benefits only from those pass users who reported that they would have driven, gotten a ride, or taken a taxi if the pass were not available. The second assumes additional benefits as a result of the publicity provided by the CCTTP program. Specifically, trip-reduction benefits are estimated for an estimated percentage of visitors who both had a car available and also first learned of shuttle service through the CCTTP program at their hotel.[4] This approach probably provides an upper bound on the actual benefits of the pass program. It assumes that without the CCTTP program, none of the travelers would have known about the shuttle service, and also that every person or group with a car available would have used their own vehicle if they did not know about the shuttle service.

The more conservative estimate is as follows:

1) The total number of pass trips on the Cape was taken from CCRTA's MDC database: 31,567 for May 25 to September 2, 2002. (Per-trip benefits for areas other than Provincetown are assumed to be the same as per-trip benefits in Provincetown.)

2) Total trips were multiplied by the percent of trips taken by visitors (84 percent) to obtain the total number of visitor trips: 26,516 during the same period.

[4] The estimate is derived by multiplying the percent of visitors with a car available by the percent of visitors who reported that they first learned of the shuttle service through the CCTTP program at their hotel. The estimate assumes independence between the responses to Question 3 and Question 5 – i.e., that whether the visitor first learned of the shuttle bus through the CCTTP program was independent of whether the visitor had a car available. The survey data did not show a statistically significant difference between the responses to Question 5 for visitors with and without a car available, although the sample size is too small to conclude that there is *not* a significant difference.

3) The number of vehicle-trips saved was calculated as:

   (26,516 person-trips/2.53 persons per vehicle[5]) * 17 percent driving if the pass were not available = 1,782 vehicle-trips.

4) The number of VMT saved was calculated as:

   1,782 vehicle-trips * 1.8 miles/trip = 3,207 VMT.

5) Emission reductions are estimated using factors derived from the U.S. Environmental Protection Agency's MOBILE6 model for light-duty cars and trucks: 1.55 g/start and 1.23 g/mile for volatile organic compounds (VOCs); 1.00 g/start and 0.99 g/mile for oxides of nitrogen (NOx). Applying these factors leads to a reduction of 14.7 pounds VOC and 7.1 pounds NOx.

The average of 1.8 miles per trip is based on a rough estimate of the average trip distance of pass users in Provincetown, which is calculated using an estimate of the distance of common trip interchanges weighted by the frequency of origin of pass trips (as determined from the MDC database). For example, the distance between both the Provincetown Inn and the Cape Inn to MacMillan Wharf is about 1.5 miles; the distance from the Sandcastle Resort to MacMillan Wharf is about 2.3 miles; and the distance from MacMillan Wharf to Herring Cove Beach is about 2.6 miles. While trip distances are relatively short, the benefits are probably most proportional to *trips* reduced, rather than VMT reduced. This is because the primary transportation problem relates to traffic congestion and parking constraints in the center of Provincetown – a function of the number of vehicles trying to enter Provincetown, not the total distance driven.

The higher estimate of benefits, accounting for publicity effects, proceeds as follows:

1) The number of total visitor-trips, as above, is 26,516.

2) The number of vehicle-trips saved is:

   (26,516 person-trips/2.53 persons per vehicle) * 73 percent hearing about the bus through the CCTTP program * 61 percent of visitors with a car available = 4,667 vehicle-trips.

3) The number of VMT saved is:

   4,667 vehicle-trips * 1.8 miles/trip = 8,401 VMT.

4) Emission reductions, as calculated above, are 38.6 pounds VOC and 18.5 pounds NOx.

[5] The number of persons per vehicle is assumed to be the same as the number of persons per party, i.e., there is one party per vehicle.

The benefits can also be reported as a reduction in peak summer day vehicle-trips into Provincetown. During July and August 2002, there was an average of 477 pass trips per day on the CCRTA system. Applying the same logic as described above, and assuming that 93 percent of all pass trips occur in Provincetown, this results in an estimate of between 25 and 66 one-way vehicle trips saved in the Provincetown area.

It should be emphasized that these estimates represent only the *incremental* benefits of the CCTTP program. The total vehicle-trip and emission reduction benefits of providing the Provincetown Shuttle service are much greater. For example, the entire number of trips on the Provincetown Shuttle between May 25 and September 2, 2001 is 105,261, about four times the number of pass trips. Generalizing some of the survey data to the entire population of shuttle riders (84 percent visitors, 2.53 average party size, and 61 percent with access to a car), and assuming that everyone with a car would have driven without the service, produces an estimated reduction of 21,318 vehicle-trips, 38,373 VMT, 177 pounds VOC, and 85 pounds NOx. Using the same methodology, an average of 302 vehicle-trips per day are eliminated in the Provincetown area during July and August.

In addition, benefits could be realized from long-distance vehicle-trips eliminated to the Cape, if the availability of the pass assisted people in their decision not to bring a car to the Cape. Because of the small sample size and the small number of visitors who identified that this was the case, the evidence on this point was viewed as insufficient to estimate a VMT or emissions savings from visitor-travel to the Cape. Nonetheless, the potential role of the CCRTA services in facilitating car-free travel to and around Provincetown should be acknowledged.

The increase in total transit trips between May 25 and September 2, 2002 also can be estimated from the survey data. A conservative estimate is based on the number of visitors who responded that they would *not* have taken transit had the pass not been available (30 percent). This estimate is:

> 26,516 total visitor transit-trips * 30 percent = 7,955 new transit trips.

A more optimistic estimate further considers publicity benefits, by assuming that all of the visitors who first heard about the shuttle through the tourist pass program (73 percent) would not have ridden the shuttle otherwise. The estimate of new trips under this scenario is:

> 26,516 total trips * (73 percent who did not know about the service) + 26,516 total trips * (27 percent who did know about the service * 30 percent who would not have taken transit without the pass) = 21,505 new transit trips.

Thus, the actual number of new transit trips resulting from the tourist pass program probably lies between roughly 8,000 and 21,500 trips during the summer 2002 peak season.

Based on ridership during the months of July and August only, the corresponding estimate is roughly 7,500 to 20,000 trips. This represents between five and 12 percent of total CCRTA fixed-route ridership (164,375 trips) during this two-month period.

■ Summary of Findings

Based on the survey findings, the availability of the Provincetown Shuttle service (regardless of the fare payment mechanism) appears to have helped to reduce vehicle-travel in the Provincetown area as well as provided a mobility benefit to both tourists and hotel staff. The fact that the majority of visitors had a vehicle available for their use suggests that the shuttle service is helping to displace vehicle-trips, primarily into Provincetown and to Herring Cove Beach, where parking can be expensive and/or scarce. Visitors appreciated the availability of the shuttle service. The service also provides a mobility benefit for hotel staff who are on the Cape only temporarily and do not have a car.

The provision of a free pass (as compared to the standard cash fare) through the CCTTP program does not, by itself, appear to have had a significant impact on peoples' decision to use the CCRTA shuttle service. While the free pass represents an added convenience, nearly 80 percent of survey respondents (both visitors and hotel staff) nevertheless indicated that they would have taken the bus even if they had to pay the fare.

It appears that the CCTTP program has had a significant benefit, though, in helping to publicize the transit service. This is demonstrated by the fact that nearly three-quarters of the visitors surveyed first heard about the service because their hotel was participating in the pass program. Anecdotal evidence from both passengers and CCRTA operators suggests that *whether the hotel promotes the shuttle bus* – including at a minimum, providing information on the service, and ideally, recommending it to guests – is the most important factor in whether a significant number of the hotel's guests use the service. A number of major hotels produce very little ridership for the service. On the other hand, hotels such as the Sand Castle Resort actively promote the service, and produce significant ridership even when they do not distribute passes.

While the availability of the shuttle has clearly affected *local* travel decisions for visitors with cars, it is not clear whether it has made a significant impact on how people choose to travel to the Cape. Provincetown is unique in that it benefits from high-speed ferry service to Boston, which is competitive or even superior to driving from a time standpoint. For most of the survey respondents who had a vehicle at home but chose not to bring it to the Cape, the availability of the shuttle service did not seem to be a significant factor in their decision. Because of the small sample size, more data would be required, though, to generalize this conclusion. As awareness of the service increases over time, its benefits may increase correspondingly.

Appendix C

Survey Instrument

Date: _______ Time: _______ Surveyor: _______________________ Survey No: _______

Cape Cod Transit Tourist Pass User Survey

Thank you for taking the time to complete this brief survey. The survey is being conducted for the U.S. Department of Transportation and the Cape Cod Regional Transit Authority, which sponsor the Transit Tourist Pass program. The results of the survey will help us provide better transit service on the Cape and also help us measure the benefits of the program.

If there is more than one person in your party on this bus, please fill out only one survey per party. You may answer the questions as a group.

1. Are you a:
   a) ___ Visitor to the Cape b) ___ Hotel Staff/Worker c) Other (specify): ___________

Please answer questions 2-5 thinking about this particular bus trip that you are making:

2. How many people are traveling in your party on this bus (including you)? ________

3. Do you or anyone in your party have a car/private vehicle available on the Cape that you could have made this trip with?
   a) ___ Yes b) ___ No

4. If you did not have the free Transit Tourist Pass, how would you/your party have made this trip? (check only one):
   a) ___ I/we would have taken the bus anyway and paid the $1.00/person fare
   b) ___ I/we would have driven
   c) ___ I/we would have gotten a ride with someone else (not on this bus) or taken a taxi
   d) ___ I/we would have walked or bicycled
   e) ___ I/we would not have made the trip

5. Did you first learn about this bus service because your hotel was providing a Transit Tourist Pass?
   a) ___ Yes b) ___ No, I already knew about it

6. Now, think about your trip to the Cape. How did you get here?
   a) ___ Car/private vehicle b) ___ Ferry c) ___ Bus d) ___ Airplane

7. If you did not come by car/private vehicle, do you (or anyone in the group you came with) own a vehicle that you could have driven to the Cape for this visit?
   a) ___ Yes b) ___ No

8. If you chose not to bring a car, did the availability of this bus service influence your decision?
   a) ___ Definitely – If the bus service were not available, I would have brought a car
   b) ___ Somewhat – It helped me decide not to bring a car
   c) ___ No – I would not have brought a car anyway
   d) ___ I didn't know this bus existed before I got here

9. You may use the back of this sheet for comments on this bus service or the Transit Tourist Pass.