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of Transportation
Federal Transit
Administration

Advanced Public Transportation Systems: The State of the Art ***Update '92***

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16. Abstract <p>This report documents one of the components of FTA's Advanced Public Transportation Systems (APTS) Program, a program structured to undertake research and development of innovative applications of advanced navigation, information, and communication technologies that most benefit public transportation.</p> <p>This report is an update to the previous State-of-the-Art which was published in April 1991. It contains the results of a limited investigation of the extent of adoption of advanced technology in the provision of public transportation service in North America. It focused on some of the most innovative or comprehensive implementations, categorized under four categories of operational tests: Market Development, Customer Interface, Vehicle Operations and Communications, and High Occupancy Vehicle Facility Operations. The concepts of the "Smart Traveler" and the "Smart Vehicle" were also discussed in detail. The objective of this effort was to increase the industry's knowledge of successful applications of advanced technologies with the expectation that this will lead to their widespread adoption.</p>			
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PREFACE

This report contains the results of a limited investigation of the extent of adoption of advanced technology in the provision of public transportation service in North America. It is an update of the prior state-of-the-art assessment produced in May 1991. The objective of this effort is to increase the industry's knowledge of successful applications of advanced technologies with the expectation that this will lead to their widespread adoption.

This research was conducted by the Research and Special Programs Administration/Volpe National Transportation Systems Center of the United States Department of Transportation and was sponsored by Ronald J. Fisher, P.E., director of the Office of Training, Research, and Rural Transportation, Federal Transit Administration. Appreciation goes to all of the researchers and professionals who supplied information for this report, most of whom are listed as contacts in the Appendix.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
 1 foot (ft) = 30 centimeters (cm)
 1 yard (yd) \approx 0.9 meter (m)
 1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in²) = 6.5 square centimeters (cm²)
 1 square foot (sq ft, ft²) = 0.09 square meter (m²)
 1 square yard (sq yd, yd²) = 0.8 square meter (m²)
 1 square mile (sq mi, mi²) = 2.6 square kilometers (km²)
 1 acre = 0.4 hectares (he) = 4,000 square meters (m²)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
 1 pound (lb) = .45 kilogram (kg)
 1 short ton = 2,000 pounds (Lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
 1 tablespoon (tbsp) \approx 15 milliliters (ml)
 1 fluid ounce (fl oz) = 30 milliliters (ml)
 1 cup (c) = 0.24 liter (l)
 1 pint (pt) = 0.47 liter (l)
 1 quart (qt) = 0.96 liter (l)
 1 gallon (gal) = 3.8 liters (l)
 1 cubic foot (cu ft, ft³) = 0.03 cubic meter (m³)
 1 cubic yard (cu yd, yd³) = 0.76 cubic meter (m³)

TEMPERATURE (EXACT)

$[(x-32)(5/9)]^{\circ}\text{F} \approx y^{\circ}\text{C}$

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
 1 centimeter (cm) = 0.4 inch (in)
 1 meter (m) = 3.3 feet (ft)
 1 meter (m) = 1.1 yards (yd)
 1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm²) = 0.16 square inch (sq in, in²)
 1 square meter (m²) = 1.2 square yards (sq yd, yd²)
 1 square kilometer (km²) = 0.4 square mile (sq mi, mi²)
 1 hectare (he) = 10,000 square meters (m²) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
 1 kilogram (kg) = 2.2 pounds (lb)
 1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

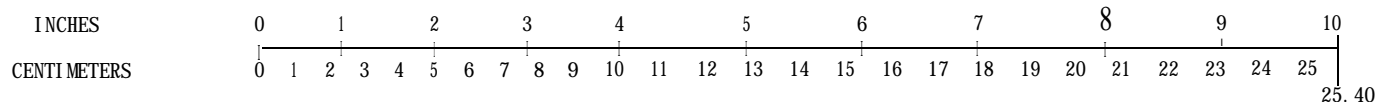
VOLUME (APPROXIMATE)

1 milliliters (ml) \approx 0.03 fluid ounce (fl oz)
 1 liter (l) = 2.1 pints (pt)
 1 liter (l) = 1.06 quarts (qt)
 1 liter (l) = 0.26 gallon (gal)
 1 cubic meter (m³) = 36 cubic feet (cu ft, ft³)
 1 cubic meter (m³) = 1.3 cubic yards (cu yd, yd³)

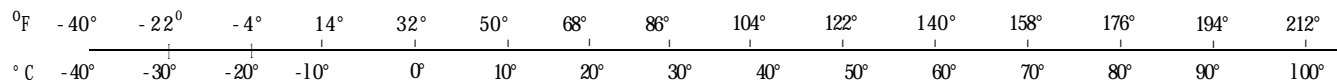
TEMPERATURE (EXACT)

$[(9/5) y + 32]^{\circ}\text{C} \approx x^{\circ}\text{F}$

QUICK INCH-CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION



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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1. Introduction	1
2. Customer-Based Systems	3
2.1 Market Development	3
2.1.1 Pre-Trip Passenger Information	4
2.1.2 Real-Time Rideshare Matching	12
2.1.3 Integrated Fare Media	18
2.1.4 Multimodal Trip Reservation and Integrated Billing Systems . .	20
2.2 Customer Interface	25
2.2.1 In-Terminal Information Systems	25
2.2.2 In-Vehicle Information Systems	29
2.2.3 Electronic Ticketing and Automated Trip Payment	32
2.3 The “Smart Traveler”	38
2.3.1 Description	38
2.3.2 Field Operational Tests Planned and in Progress	40
3. Vehicle and System-Based Systems	43
3.1 Vehicle Operations and Communications	43
3.1.1 Automatic Vehicle Location	44
3.1.2 Transit Operations Software	55
3.1.3 Automated Demand-Responsive Dispatching Systems	57
3.2 HOV Facility Operations	65
3.2.1 Traffic Signal Preferential Treatment	65
3.2.2 High Occupancy Vehicle Lane Control	67
3.2.3 Automatically Guided Transit Buses	68
3.3 The “Smart Vehicle”	71
3.3.1 Description	72
3.3.2 Field Operational Tests Planned and in Progress	74
4. FTA-Sponsored Field Operational Tests and Research	78
Appendix: List of Contacts	81

EXECUTIVE SUMMARY

This report examines the implementation status of advances in technology in the public transportation industry. The ready availability of low-cost, reliable microelectronics has opened up many new opportunities for enhanced information, communications, and control strategies for transit and ridesharing modes.

Many public transportation agencies have been applying recent technological advancements to improve services. To help develop, evaluate, and publicize these opportunities, the Federal Transit Administration (FTA) has established the Advanced Public Transportation Systems (APTS) Program. FTA's objective is to increase the industry's knowledge of successful applications of advanced technologies with the expectation that this will lead to their widespread adoption.

This report documents a limited investigation of the extent of adoption of advanced technology in the provision of public transportation service in North America. It is an update to a similar report published in May 1991. It was not an exhaustive search of every city or transit authority which has tested, planned, or implemented an advanced technology concept. Rather, it focused on some of the most innovative or comprehensive implementations, categorized broadly under four different types of operational tests: Market Development, Customer Interface, Vehicle Operations and Communications, and High Occupancy Vehicle Facility Operations.

MARKET DEVELOPMENT

The goal of market development projects is to increase the utilization of high occupancy vehicle modes. By providing travelers, especially regular commuters, with traffic and transportation service information prior to embarking on their trips, travelers can make the most informed choices of modes and routings.

Pre-Trip Passenger Information

Pre-trip traveler information systems reach trip makers in their home or office and provide timely information on transit routes, schedules, transfers, and fares. When linked to

automatic vehicle location systems, pre-trip traveler information systems can provide ‘real-time updates on system status and expected arrival times.

Several North American transit systems have enhanced pre-trip information systems in operation or are actively investigating such systems. The most basic of these are computerized databases that provide agents with route, schedule, and fare information to use in reply to telephone inquiries. Some provide trip planning information as well.

The more advanced systems allow callers to use touch-tone telephones to request schedules and fares and to enter origin and destination’ if trip planning is available. Many of these employ a computer-generated voice which lists options available and gives the final information. Among those who have implemented systems of this type are transit agencies in Miami, Florida; Ottawa/Carleton, Toronto, and Kitchener, Ontario; Long Island Railroad, New York; Baltimore, Maryland; Winnipeg, Manitoba; Los Angeles, California; Denver, Colorado; Columbus, Ohio; and Victoria, British Columbia.

Several North American transit systems have incorporated data generated by their automatic vehicle location systems to enhance the information available to transit users. Among those who have implemented systems that provide specific real-time bus location information to transit users via telephone are transit systems in Halifax/Dartmouth, Nova Scotia; Hull, Quebec; and San Antonio, Texas. A few transit agencies also are planning to use real-time vehicle data to improve the level of service provided to paratransit users.

Several transit agencies, including those in Ann Arbor, Michigan, and Champaign/Urbana, Illinois experimented with the use of public access cable TV as a medium to provide information on current bus location, direction, and estimated arrival time at key stops. A similar method is employed in teletext information systems that are, common in Western Europe, but not the U.S. (updated traffic information is being ‘reported in this way in Los Angeles). They operate by invisibly encoding alphanumeric data onto conventional television signals, which are then read by a decoder attached to the TV set.

Real-time Rideshare Matching

Real-time rideshare matching features an automated system for requesting and responding immediately to a request from a traveler for a trip in a carpool or vanpool. In recent years,

ridematching has become a highly automated process in which people wishing to join or form a carp001 or vanpool can do so by a telephone call (or sometimes via personal computer) to a matching service. This match, however, is usually for a trip that is regularly taken (e.g., home-work-home trip, 5 days a week).

Real-time matches could serve commuter trips, but more importantly, could be made for travelers wishing a ride for a one-way or round-trip on a one-time, short-notice basis. This type of real-time ride matching is not currently available through automated means in North America, but is being developed in several locations, including:

- Houston, Texas - The initial instant rideshare matching demonstration will focus on the I-10 corridor. Four general technologies - telephone, television, radio, and videotex - were examined for application in the project. The system requires an interactive user interface. Therefore, it was recommended that a telephone-based system be used for the initial implementation, which could be expanded to a combined touch-tone telephone/videotex system in the future.
- Sacramento, California - Sacramento will be the site of a real-time rideshare demonstration, which should be operational by December 1992. Existing rideshare software packages are currently being evaluated for potential use.
- Bellevue, Washington - The Transportation Management Association is testing a combination of various advanced technologies to improve ridesharing, including cellular telecommunications, voice mail, and computerized real-time information processing.

Integrated Fare Media

Integrated fare media are tickets that can be used for all modes, such as a magnetic stripe card that could be used for both bus and subway fares. There are several North American transit systems that are utilizing integrated fare media that can be used on different modes operated by one or more transit operators. Examples that are described in this report include:

- TransLink, an adaptation of the Bay Area Rapid Transit farecard, which can be used on bus and rail. It is being operationally tested in March and April 1992 on one bus route, and will be fully operational by Fall 1992.
- The Los Angeles County Transportation Commission project, which is very similar to the TransLink program. This project involves 300 buses operated by several transit companies.

Multimodal Trip Reservation and Integrated Billing Systems

Multimodal trip reservations would allow a traveler to obtain trip reservations and tickets for an entire multimodal trip (portal-to-portal) from the initial carrier through interline agreements. An integrated billing system is one in which bills for the purchase of fares for all modes are generated from a central source.

There are no known multimodal trip reservation systems or integrated billing systems, operating in North America, with the exception of the airline and passenger rail industry. However, several of these systems are under development through the “Mobility Manager” concept, a mechanism for achieving the integration and coordination of transportation services offered by multiple providers, involving ‘a variety of travel modes and multiple sources of funding. The Mobility Manager would be a clearinghouse of information on travel choices and service providers, and would process the associated financial transactions. FTA is currently sponsoring Mobility Manager demonstrations in Norfolk, Virginia and Medford, Oregon.

CUSTOMER INTERFACE

Customer interface provides services to the passengers of a system to make their travel easier. This includes information on arrival times, the general condition of the system, and simplified methods of payment. Each of the strategies is designed to ease trip-making, from the point of departure to arrival at the destination.

In-Terminal Information Systems

In-terminal information systems consist of electronic and computer display devices located at transit stations and/or enroute stops, providing up-to-date travel information on delays, cancellations, reroutings, and terminal layout and services. These systems may involve interactive traveler input and can be designed to accommodate disabled travelers.

Although automatic displays announcing the arrival of the next two or three trams are well established in the areas of light rail and heavy rail, they are not yet a regular feature in bus stations. Plans are underway to incorporate traveler information systems with some of the new demonstrations of automatic vehicle location (AVL) systems.

- Anaheim, California - Caltrans is developing a concept plan for a project which will provide real-time information to travelers at bus stops and transfer stations as well as in transit vehicles by using display boards or smartkiosks.
- Baltimore - The Mass Transit Administration plans to employ a traveler assistance network in its downtown terminal in connection with its new AVL system. This public information system network will display accurate real-time arrival of a connecting service on monitors located at key transit stops and transfer points.
- Denver - Kiosks are located in the two downtown transit stations along with electronic display systems that list the next three departures. Currently, these are based on printed schedules rather than real-time data. The agency is considering supplementing these with real-time updates, received from the AVL system they are currently installing.
- Houston - Metro has deployed interactive terminals in three key locations in downtown areas. Users touch the screen at their preferred destination and are shown a route to that point. They also can receive a printed version of their directions to take with them. The machine is multilingual and route changes can be input by modem from the central office.

In-Vehicle Information Systems

In-vehicle information systems consist of technical innovations supporting the transit user enroute and the vehicle operator. Travelers are aided by on-board displays and communication devices providing information on routes, schedules, and connecting services. Additional information available to vehicle operators includes displays and communication systems indicating correctable schedule deviations, requirements to wait for connecting services, and on-board mapping and geographic information system (GIS) support.

The Americans with Disabilities Act (ADA) requires all fixed route transit vehicles to provide both visual and audio information to passengers, identifying major intersections and key transfer sites. Thus, increased interest in in-vehicle information systems can be expected, not only to meet legal requirements, but also to appeal to all riders. The continued improvement of AVL systems will further increase the potential of these systems.

The U.S. Department of Transportation's ADA requirements also have stimulated new interest in an area which previously had received limited attention: in-vehicle-navigation aids, especially for paratransit services.

- Durham (North Carolina) Area Transit Authority is currently testing the "TalkingBus" Digital Recorder system, which announces stops and other necessary information, on one of its busiest routes.

- Foothill Transit in the San Gabriel Valley of California plans to have recorders installed on eighteen of its buses soon.
- Salem, Oregon is about to install a system on its Salem Area Transit.
- A voice annunciator is being tested in Dallas, Texas; Long Beach, California; New York City, New York; Washington, D.C.; and Wilmington, Delaware. It is activated when the bus door opens and a message announcing the route number and destination of the bus is broadcast to passengers waiting at the stop. Messages also can be bilingual.

On-board communication with the drivers has not advanced as rapidly. Automatic vehicle location systems often include a panel which indicates to the driver that the bus is early, late, or on time. However, no other information is regularly shared with the drivers. Map navigational devices, which are being tested in automobiles through Intelligent Vehicle-Highway Systems (IVHS) studies in Los Angeles, California and Orlando, Florida, have not yet been tested on transit vehicles. The Ann Arbor Transit Authority tested an on-board navigation system on its paratransit vehicles but is now in the process of updating its whole AVL system. Other paratransit operations have not yet begun tests of on-board navigation systems.

Electronic Ticketing and Automated Trip Payment

Electronic ticketing is the automated generation of tickets and automated fare collection, which allows the collection of detailed information on revenue, passengers, and origins and destinations. Automated trip payments are those payments made without a manual exchange of cash. Often, electronic ticketing provides automated trip payment through the use of either magnetically-encoded farecards or Smart Cards.

Electronic ticketing and automated trip payment are technologies that are beginning to be utilized in several North American transit agencies. Examples that are provided in this report include:

- Chicago, Illinois Regional Transportation Authority's acceptance testing of Smart Cards and associated equipment as part of the development of their Payment and Control Information System,
- City of Phoenix, Arizona Transit System's Bus Card Plus Program, involving the use of a transit credit card,
- The potential development of a Smart Card system for the Washington Metropolitan Area Transit Authority,

- * The Twin Cities (Minnesota) Smart Traveler project, which will involve the use of Smart Cards for the Metro Mobility system for the disabled,
- Virginia Railway Express's use of a vending machine for ticket sales, which only accepts credit or debit cards,
- Los Angeles Department of Transportation's Smart Card demonstration, and
- Ann Arbor Transportation Authority development of a radio frequency (RF) Smart Card for transit and parking lot use.

THE "SMART TRAVELER"

The "Smart Traveler" is a person who has access to reliable, real-time information in order to make travel decisions that involve high-occupancy vehicles and transit. The concept of the Smart Traveler encompasses several technologies, including Smart Cards, audiotex and videotex, telephones, cable television, personal computers, and geographic information systems. In each location, some subset of these technologies will be made available to travelers.

Currently, there are four Smart Traveler projects funded by FTA: Bellevue, the State of California, Houston, and St. Paul, Minnesota.

VEHICLE OPERATIONS AND COMMUNICATIONS

The principal goal of vehicle operations and communications techniques is improved management of existing fleet resources through technological innovation.

Automatic Vehicle Location

Automatic vehicle location is a means of monitoring the movement of a fleet of vehicles. Transit agencies have been using AVL for rail operations for several years to control operations and to help maintain schedule. The technology is now available to do the same with buses.

AVL continues to be tested and implemented extensively by transit agencies throughout the world. Although more widespread in Europe, there are several AVL implementations and tests in progress throughout North America, including the following.

- The Tidewater Transportation District Commission in Norfolk, Virginia has equipped 160 buses with a signpost-based system that also includes three remote bus component alarms: engine temperature, low air (brakes), and oil pressure.

- The Mass Transit Administration in Baltimore has recently completed a test of a LORAN-C system on 50 of their 900 buses. Computer aided dispatch was included to aid in necessary adjustments to operations. The test results have prompted the agency to issue an RFP for their whole system, which will probably be global positioning system (GPS)-based. The full implementation is one of four to be evaluated by FTA and the Research and Special Programs Administration/Volpe National Transportation Systems Center (RSPA/Volpe Center) as part of the APTS Program.
- The Toronto Transit Commission has completed a phased implementation of a signpost system on all of their 2,300 buses and streetcars. Their operation also includes automatic passenger counters on 10 percent of their buses.
- The Regional Transportation District in Denver is installing a GPS-based system on 800 buses. The system will be used for planning information, operational improvements, and passenger information systems. The system is one of the four to be evaluated by FTA and the RSPA/Volpe Center as part of the APTS Program.
- The transit agencies in Milwaukee, Wisconsin and Dallas also are installing GPS-based systems, which will be evaluated by FTA and the RSPA/Volpe Center as part of the APTS Program.

There are more than a dozen other systems in North America, and many in the rest of the world, either in operation or planned. The principal location technology for older systems is signposts and odometers, and for newer implementations, GPS. There are also a few examples of dead reckoning and LORAN-C, but these are somewhat less common.

Transit Operations Software

Transit operations software performs and integrates network and operations planning, vehicle and crew scheduling, computer-aided dispatching (CAD), marketing, and management and administration. Currently, there are no examples of fully-automated real-time operations software being used in North America. However, there are examples of partially automated operations control systems in Boston, Massachusetts and Toronto.

Automated Demand-Responsive Dispatching Systems

Automated demand-responsive dispatching systems schedule trips, dispatch shared-ride vehicles, and perform accounting and billing functions through the use of computers and advanced communications. More and more paratransit systems are using systems that contain such advanced technologies as geographic information systems, two-way mobile data

communications, smart cards, and automatic vehicle location systems. CAD is an integral part of many of these systems.

There are several automated demand-responsive dispatching systems that have been implemented in North America described in this report.

HOV FACILITY OPERATIONS

High occupancy vehicle facility operations include those technologies designed to improve the flow of high occupancy vehicles (HOVs) by giving preference to these vehicles on existing facilities or by constructing special guideways to control their movement.

Traffic Signal Preferential Treatment

In the context of APTS, traffic signal preferential treatment for buses has the potential to increase intersection people throughput, by facilitating the movement of these high occupancy vehicles. Preferential signal treatment has not been widely implemented in the U. S . Opponents argue that it disrupts traffic flow. However, if a bus is given preferential treatment only when it is behind schedule, disruption of other traffic would be minimal. Further, improvements in bus schedule adherence may entice travelers to switch to this higher occupancy vehicle mode.

There are only a few planned or operational tests in the U.S. The CTA in Chicago plans to test preferential treatment for buses running behind schedule on a major arterial.

High Occupancy Vehicle Lane Access Control

HOV lanes often are used by vehicles not carrying the required number of passengers. These violators diminish the utility of these lanes to rightful users. The lanes usually are monitored by police who count the number of people in each vehicle manually - an effective, but expensive means of enforcement.

APTS has the capability to reduce the number of violators through two separate strategies. The first is to restrict access to the lanes by means of a barrier which would open to allow only rightful users to pass. Rightful users would have their cars fitted with transponders to identify themselves. Applications of access control in the U.S. thus far have

been limited to low-speed applications, primarily at airport parking lots such as Washington National Airport.

The other automatic enforcement strategy would be to place cameras at a strategic location to view the interior of the vehicle. The images would then be processed by artificial intelligence software, capable of “counting” the passengers. Violators would be recorded and prosecuted. To date, this system has not been implemented, nor is it planned. The software is not yet available, and tests in the Seattle, Washington and Los Angeles areas have shown that it is difficult to get an accurate picture of the vehicle’s interior.

Automatically Guided Transit Buses

Automatic guidance for transit buses has been proven to increase the speed, volume, and boarding capability in urban settings. Automatic guidance permits operation in a narrower right-of-way than is needed for manually-steered buses. There are two types of guidance systems for buses - track guidance and electronic guidance. Track guidance consists of mechanical direction of the bus by physical contact with guiderails at the edges or in the center of the track. Electronic guidance consists of a cable buried in the road, which emits a signal that is collected by a transducer on the bus and actuates the steering system.

There are currently no automatically guided transit bus systems in North America. However, the concept of automatic guidance is being studied at the University of California as part of the Partners for Advanced Transit and Highways (PATH) program. PATH researchers are investigating the development of longitudinal and lateral control for all types of vehicles, including high occupancy vehicles.

There are several examples of automatically guided bus systems in Australia, England and Germany that are presented in this report:

- Furth, Germany - demonstration of electronic guidance,
- Rochefort, Belgium - controlled track guidance system,
- Essen, Germany - mechanical track guidance,
- Adelaide, Australia - mechanical track guidance, and
- Birmingham, U.K. - test of mechanical track guidance.

THE “SMART VEHICLE”

The “Smart Vehicle” is another of the concepts included in the APTS program. It incorporates the vehicle-based APTS technologies and innovations for more effective vehicle and fleet planning, scheduling, and operations. The technologies and innovations involved in this concept include automatic vehicle location, automated demand-responsive dispatching systems, HOV verification, and automatic guidance equipment. Each Smart Vehicle does not have to be equipped with all of these features. Some sub-set of these will be present, depending on the environment in which the specific application is employed and the needs of the users and service providers.

There are Smart Vehicle projects being funded by FTA in Ann Arbor, Chicago; Portland, Oregon; Denver; and Baltimore.

1. INTRODUCTION

Purpose of Report

The ready availability of low-cost, reliable microelectronics continues to open up many new opportunities for enhanced information, communications, and control strategies for transit and ridesharing modes. This report updates the implementation status of advances in new technologies in the public transportation industry during the past year.

Background

The 1980s saw rapid advancements in the development of information and communication technologies. During this period, many public transportation agencies have been employing certain of these technologies to improve the services they offer. Automated vehicle location and monitoring, automated guideway operations, and computerized dispatching were some of the earliest applications of advanced technologies. However, the greatest opportunities for public transportation enhancement through advanced technologies are just unfolding as the private sector development of these technologies accelerates.

In an effort to assist the development and evaluation of these opportunities, the Federal Transit Administration (FTA) has established the Advanced Public Transportation Systems (APTS) Program. Through in-service operational tests, evaluations, and publication of results, FTA's objective is to increase the industry's knowledge of successful applications of advanced technologies with the expectation that this will lead to their widespread adoption. The improved public transportation services that will result should attract more riders to transit and ridesharing modes, thus producing the added public benefits of reductions in traffic congestion, air pollution, and energy consumption. This state of the art update is just one of the initiatives of the APTS program.

Scope

This effort was a short-term investigation of the past year's developments and advancements in the adoption of new technology in public transportation services in North America. It was not an exhaustive search of every city or transit authority which has tested,

planned, or implemented an advanced technology concept. Rather, it focused on some of the most innovative or comprehensive implementations of new technology approaches.

Further, it must be emphasized that this study did not encompass an examination of advanced technology applications in Europe, Japan, or other foreign countries. Nevertheless, where North American applications were few or nonexistent, foreign examples were noted if they happened to be known to members of the study team. They were included in this report only for the purpose of indicating advanced technology approaches that are in use elsewhere and, therefore, which could soon be tried in the U.S.

Report Organization

This report is organized in accordance with FTA's Advanced Public Transportation Systems Program. Market Development, Customer Interface, and the "Smart Traveler" concepts are discussed under the heading of Customer-Based Applications. Vehicle Operations and Communications, High Occupancy Vehicle Facility Operations, and the "Smart Vehicle" concepts and applications are discussed under the heading of Vehicle and System-Based Applications. These sections are preceded by an Executive Summary and this Introduction, and are followed by an Appendix containing a comprehensive list of the individuals contacted during this study.



2. CUSTOMER-BASED SYSTEMS

Two basic types of Advanced Public Transportation Systems are discussed in this report. Each of these is defined by their basic application and whether they center around transit and rideshare current and prospective users (customer-based), or transit and rideshare *vehicles* (vehicle and system-based). These two groups overlap a great deal; consequently, applications in many sites will be discussed in both chapters.

The first type, customer-based systems, centers around customers and potential customers of transit and rideshare services. The technologies, innovations, and applications in this area are those that make high occupancy vehicle (HOV) options more attractive and more useful. There are two different types of customer-based systems:

- Market Development
- Customer Interface

Each of these is discussed in this chapter.

2.1 MARKET DEVELOPMENT

Market development projects are directed at increasing the utilization of high occupancy vehicle modes. When travelers, especially regular commuters, are provided with traffic and transportation service information prior to embarking on their trips, they can make the most informed choices of modes and routings. If provided with transportation service information, especially in real time, it is anticipated that many travelers will choose to make their trips in high occupancy vehicles rather than in single occupant vehicles. Marketing strategies also include projects to make buses, carpools, and vanpools more convenient or easier to use.

Market development includes such activities as pre-trip traveler information systems, real-time rideshare trip matching, integrated fare media, multimodal trip reservation, and integrated billing. Each of these activities is discussed in this section.

2.1.1 Pre-Trip Passenger Information

Pre-trip traveler information systems reach trip makers in their home or office and provide timely information on transit routes, schedules, transfers, and fares. In some cities, carp001 options are offered as well. Passenger information can be provided through a variety of conventional and high technology methods including telephones, direct computer links, and cable television, When linked to automatic vehicle location (AVL) systems which track transit vehicles, advanced traveler information systems are able to provide real-time updates on expected transit vehicle arrival times and warn transit users of delays.

State-of-the-Art Summary

A number of North American transit agencies have enhanced pre-trip information systems in operation, and others are actively pursuing such systems. Most widely deployed are automated telephone services that provide route, schedule, and fare information. These systems enable transit systems to process far more calls more efficiently with more consistently accurate information. The earliest automated telephone systems provided primarily schedule information, while more complex systems now provide trip planning information as well. Generally, they employ a computer-generated voice which lists options available. Callers use touch-tone telephones to request schedules and fares, and to enter origin and destination if trip planning is available.

A few transit systems also are exploring direct computer links and cable television information systems which can share scheduling and routing information. With the increase in installation of AVL bus tracking systems, it will be possible to relay real-time schedule information to prospective transit users. If real-time transit data is presented in relation to parallel information on traffic congestion, it is expected that increasing numbers of travelers will consider traveling on reliable public transit.

Success in diverting travelers from single occupancy vehicles depends on the quality and effectiveness of pre-trip information. The recent increase in operations which provide trip planning information is most encouraging. The scope and range of informational projects also is indicative of the rising interest in this area. Since many projects are just beginning, it will

be necessary to monitor these pre-trip information services and assess their relative effectiveness both in technical operation and in traveler response.

Applications

Dade County, Florida

Most systems still retain operators to respond to calls on rotary telephones. Metro Dade County Transit in Miami, Florida, however, has instituted a voice-activated information request system. This system recognizes a voice request for information regardless of accent, digitizes the request, and then responds by relaying back appropriate route information to the consumer using a voice synthesizer.¹

Dade County, as well as all of the more complex trip planning programs, still employs clerks to relay the digitized request of the caller to the computer which stores schedules and geographic information systems (GIS) route maps. A much smaller staff, however, can handle a far greater volume of calls. Once the computer generates the response on the schedule or best route, that information is relayed back to the caller by using a synthesized voice.

Ottawa, Ontario, Canada

One of the earliest and best established systems was the “560” telephone system provided by the Ottawa-Carleton Regional Transit Commission (OC Transpo). Intended as a scheduling update, the fully automated system provides the caller with the number of minutes until the next two buses are due at a particular stop. Each bus stop has a particular code number that the caller enters when requesting the schedule information from the computer. The reply also provides bulletin status reports on delays caused by accidents or storms. First initiated in Blackburn Hamlet in 1980, the 560 telephone system is now available for stops all over the Ottawa region.²

[1] Louis Revas, Metropolitan Dade County Transportation Authority, Miami, Florida.

[2] Joel Kaufman, Ottawa-Carleton Regional Transit Commission. Ottawa, Ontario, Canada.

Long Island Railroad, New York

A new sophisticated travel information system, “Teletrip” , was designed for the Long Island Railroad by Next Generation, Inc. in February 1990. It is capable of handing seventy-two incoming calls simultaneously as compared to the sixteen that the railroad’s old system could handle at one time. In total, the system handled thirty-two percent more calls in 1990 than in 1989 with the same staffing level. The system features a computer generated voice that provides fare and schedule information to callers with a touch-tone telephone. Plans call for adding a second language to the interactive voice system.³

Baltimore, Maryland

The Mass Transit Administration of Maryland has found that their new system, also designed by Next Generation, Inc, is saving money and alleviating the problem of call blockage. Now ninety-two percent of calls are getting through, compared to only fifty percent in 1989 before the new system was installed. More specific information on schedule times will be added in the second phase of the program, which is to go into effect in Spring 1992, in hopes of attracting more callers to the automated system. Currently, only thirty percent choose the automated option.⁴

San Antonio, Texas

Concern about a computer taking the place of an agent is widely held in San Antonio, Texas, where the new automated telephone scheduling service became operational in October 1991. There the new system is marketed as “augmenting the customer service operations, ” to alleviate these concerns.⁵

[3] “Automated Telephone Information Means More For Less,” Passenger Transport, Nov. 25, 1991.

[4] Ibid.

[5] Ibid.

TeleRide Sage

Several vendors are active in the broader range computerized trip planning area including TeleRide Sage, Megadine Information Systems, Commuter Transportation Services, Inc., Oracle Communications, and Tidewater Consultants, Inc. TeleRide Sage of Toronto, Ontario, Canada offers a modular series of software packages (TeleTrans) which assist with transit vehicle management, vehicle maintenance, computer dispatch, and radio communications. It also offers software to handle automated telephone information. To date, more than seventy transit systems use some of this software. TeleRide Sage public information telephone answering packages are functioning in Toronto and Kitchener, Ontario, and Winnipeg, Manitoba.^{6,7}

Megadine Information Systems

Megadine Information Systems provides a customer information system, using a touch-tone telephone interface to an operator. The system (PARIS) is operational in four locations:

- Southern California Rapid Transit District (SCRTD), Los Angeles, California;
- Metro Dade County Transportation Authority (MDTA), Miami;
- Regional Transportation District (RTD), Denver, Colorado; and
- Central Ohio Transit Authority (COTA), Columbus, Ohio.

The largest application, SCRTD, supports sixty agents and ten thousand inquiries/day. The system runs on mainframe computers or minicomputers, depending on the system size, and costs \$400,000-\$550,000 per installation, exclusive of hardware. The system incorporates voice synthesis for part of the operator/customer interface. The route-finding algorithm can distinguish physical barriers and integrate complex routings among multiple transit agencies. Real-time links to AVL are in the development plans.'

[6] "Products Available in Transit," Passenger Transport, Nov 25, 1991.

[7] Doug Baxter, TeleRide Sage.

[8] Robert Chapman, Megadine Information Systems.

Commuter Transportation Services, Inc.

TransStar is an automated transit trip planning system available from Commuter Transportation Services, Inc./CTS Pathways. The program can provide the customer with information on carrier, route, destination, boarding location, fare, scheduled time for departure, and return trip information. A customer service representative enters the preferred origin and destination points identified by a caller. In a few seconds, up to three routes, including transfers, are displayed complete with name of carrier, boarding location, scheduled departure time, exact trip end, fare, and return route information. Optional information such as wheelchair accessibility and shortest walking distance or lowest fare also can be provided. If desired, a printed copy of the itinerary may be mailed to the caller for a permanent record. Riverside Transit in California is currently testing this system and has reported a thirty to fifty percent increase in the number of calls about transit trip making. They are able to handle this increase with the same number of clerks because of the quicker turnaround time per call.^{9,10}

Oracle Communications

BusLine, an Oracle Communications product, offers twenty-four hour telephone answering and provides human quality voice information on next available bus and fares. It runs on any 286/386 microcomputer, uses commercially available phone handling equipment, and provides user friendly menus which minimize training time. A wide variety of options are available including trip planning. Responses can be made available in languages other than English to non English-speaking residents. BC Transit in Victoria, British Columbia, Canada currently is using BusLine to provide' general information, schedules, fares, and next bus information. The trip planning menus are in final development and testing and will be operational by the end of the year. Whistler, British Columbia, a resort community with a small six bus transit system, plans to start a similar system in April 1992.^{11,12}

[9] "TranStar, Automated Transit Trip Planning System,' Informational Brochure, Commuter Transportation Services, Inc.

[10] "Use of Computerized Transit Trip Planning Grows in California," The Urban Transportation Monitor, Feb, 7, 1992.

[11] "BusLine," Informational Brochure, Oracle Communications.

[12] Ron Drolet, British Columbia Transit, Victoria, British Columbia, Canada.

Tidewater Consultants

‘The Automated Travel Information System from Tidewater Consultants is a microcomputer-based system intended primarily to assist the agent with responses to telephone calls for trip planning. It requires the agent to enter the parameters identified by the caller - such as preferred times of departure and arrival, lowest fare, accessibility - as well as points of origin and destination. The computer then responds with “the best route available” given the requirements of the caller. It even can indicate a combination of bus and train. It also can provide responses in one or more specified languages. From their first installation developed for the Peninsula Transportation District Commission in Virginia, Tidewater has developed far more complex systems--“Easy Rider”, for the Washington (D.C.) Metropolitan Area Transit Authority, “On-Line Travel Information System” for the New York City (New York) Transit Authority, and is now developing the “Automated Travel Information System” for San Diego (California) Transit Corporation. The San Diego system will be combined with a bilingual interactive voice system. In developing the Easy Rider system in Washington, Tidewater replaced an outdated automated transit information system which used large minicomputers with a modular LAN-based design the allows for very fast response times and will permit future expansion without any negative affect on system speed. The new system increased call capture from eighty-two to ninety-three percent and decreased response time from one minute to 2% seconds. The New York City Transit Authority’s new OTIS ‘encompasses buses, trains, and ferries over the five boroughs of New York City with a data base of all streets, intersections, and landmarks in the area. In addition to route and schedule requests, agents can use OTIS to display a map of the area around the caller’s origin or destination, mail or fax itineraries, display a description of the bus stop or train station, and report service delays. ^{13,14}

[13] “Automated Travel Information System, ” Informational Brochure, Tidewater Consultants, Inc.

[14] Andi Overton, Tidewater Consultants, Inc.

Cable TV; Personal Computers

To date, few North American transit systems have experimented with providing pre-trip transit information through computers or cable TV. These services are widely used in Europe. The technology exists in North America as well, but thus far has only been tested in relation to highway traffic. The California Department of Transportation (Caltrans) is experimenting with several ways of distributing pre-trip information in the Los Angeles area. Commuters can use a commercially available decoder and tune in to Channel 46 from 6 A.M. to 7 P.M. and receive a teletex broadcast giving highway conditions in real time. The Minneapolis, Minnesota Guidestar program also provides pre-trip cable TV broadcasts indicating location of traffic congestion and overall speed of travel. Neither of these systems currently include reports on transit alternatives.

The Twin Cities in Minnesota plans to institute TravLink, an interrelated automatic vehicle location and traveler information system. This program will provide relevant transit service and traffic data to transit users and ridesharers at home or work, enabling them to do pre-trip planning. TravLink also plans to test applications of audiotex and videotex systems using real-time data.

The Ann Arbor Transit Authority (AATA) was intending to provide real-time transit information on cable TV, but plans have been delayed since they are going to replace their vehicle location system.

Dulles Corridor, Virginia

The Dulles Corridor project, entitled DATIS (Dulles Area Travel Information System), is intended to test new techniques for collecting and disseminating traffic condition information in the area near Dulles International Airport in northern Virginia. The project will involve the use of live video cameras mounted on fixed-wing aircraft and helicopters to monitor traffic conditions. The cameras will transmit information about highway accidents and other conditions to local and state traffic managers. This broad ranging inter-jurisdictional project is intended to provide information on service delays on MetroRail as well as on parking availability in park-and-ride lots near MetroRail and at the airport. It will use cable-based systems to provide

information in the home and work place and at shopping malls. Data will be displayed on television monitors (videotex) or in print (teletex). Initial test designs are anticipated.^{15,16}

California Smart Traveler

Plans call for a major test of similar applications in connection with the California Smart Traveler projects in which public and private sectors will jointly test an audiotex/videotex based Advanced Traveler Information System at five different sites. Audiotex/videotex will enable residential and business users to use telephone lines to interact with remote computer systems and get timely transportation information. Callers will learn current information about traffic conditions, congestion type and locations and, at the same time, learn about transit routes and schedules and immediate rideshare matching opportunities.¹⁷ Audiotex involves using an interactive computer system with touch-tone telephones as the input device and voice messages as the output device. A videotex system would be used to develop an instant carpool by providing a map showing directions to the rider's location displayed on the driver's videotex monitor. This videotex terminal also could be used to access electronic directories, weather forecasts, and tele-banking facilities. Electronic directories and navigational maps that will feed into such systems are now being developed by Etak.

Houston Smart Traveler

The Houston (Texas) Smart Traveler program will work toward the development and provision of a real-time traffic and transit information system for commuters in the Katy freeway corridor. A variety of technologies, including touch-tone telephones, cable television, and videotex terminals will be introduced to provide up to the minute information on bus services, rideshare opportunities, and traffic conditions. The goal of the demonstration is to give commuters real-time travel information before they leave home and enable them to choose alternative routes or alternative modes. Since ninety-one percent of the respondents to a recent

[15] The Urban Transportation Monitor, Nov. 1991.

[16] Stacy Marlbert, Dulles Area Travel Information System.

[17] Robert Behnke, AEGIS Transportation Information Systems, Inc.

survey of travelers on the Katy Freeway indicated that they currently change their travel plans because of radio traffic reports, program developers anticipate heavy use of the more complete and accurate pre-trip information.¹⁸

Bellevue, Washington

In Bellevue, mobile communications such as cellular phones will be used to increase carp001 ride matching. A two-year operational test, which involves public and private sector use of mobile communications to increase usage of HOV lanes, is nearing completion. In the future, instant ride matching is anticipated. The concept will enable a potential rider to use a mobile cellular telephone to contact a participating driver passing nearby and encourage the driver to divert slightly for the pick-up.”

2.1.2 Real-Tie Rideshare Matching

Automated ride matching services for carpools or vanpools can be provided via telephone or personal computer. Software for these services are listed in Table 2.1.²⁰

State-of-the-Art Summary

Real-time ridematching is not currently operational in North America. However, it is being planned in Houston as part of their “Smart Commuter” IVHS Demonstration Project, and in California and Bellevue as part of their FTA Smart Traveler projects. An update of each of these projects follows.

[18] Katherine Turnbull, Texas Transportation Institute, Texas A&M University System.

[19] “Bellevue Smart Commuter, ” FTA project description.

[20] This list was provided by the Association for Commuter Transportation (ACT). (Inclusion on this list does not constitute an endorsement by ACT.)

Table 2.1
Automated Ride-Matching Services

Software Name	Company	Contact	Phone
TRANSMAX	C> Systems Santa Barbara, CA	Sharon Bolstad	805-963-7283
RIDESTAR	Commuter Transportation Services, Inc. Los Angeles, CA	Linda McCurdy	213-380-7750
SUPERPOOL RIDETECH RIDESHARE	CommuteTech Union, NJ	Dan Reichard	201-686-8805
MICROCRIS	COMSIS Corp.	Martin Fertal	412-279-9110
POOLMATCH	Crain & Associates Systems West Los Angeles, CA	Jesse Glazer	213-473-6508
RIDESHARE LINK	Fone Link, Inc.	Paul Alfrey	714-631-9065
MATCHMAKER	Public Policy Systems, Inc.	Bryndley Burton	714-863-7030
RIDEMATCH	Spokane Ridesharing Spokane, WA	Arnold Stone	509-325-6000
EZ-RIDER	STW Communications	Jennie Keeran	604-929-3835

Applications

Houston, Texas

In Houston, the “Smart Commuter” IVHS Demonstration Project is beyond the conceptual stage and is beginning to apply to a variety of funding sources (Federal, state, local, private, and in-kind services). The project will test the potential for gaining more efficient use of major travel corridors through greater utilization of high occupancy commute modes and shifts in travel routes, and changes in travel time through the application of innovative communications technologies. The demonstration is based on the hypothesis that commuters who have quick and easy access to relevant, accurate, and up-to-date information on existing traffic conditions, bus routes, bus schedules, how to use the bus, and instant ridematching services in their home and work place will be more likely to use public transportation and other

high occupancy commute modes. The project is coordinated and compatible with the long-range goal of the Houston Intelligent System (HITS), which is to improve the mobility of people and goods, and reduce the environmental impacts of the transportation system through an accelerated and innovative program utilizing advanced technologies.

The project includes two components: one that focuses on the suburb-to-downtown travel market in the I-45 North corridor, and the other that focuses on the suburb-to-suburb travel market in the I-10 West corridor and the Post Oak/Galleria (uptown) area. The I-10 West corridor provides the opportunity to test the use of a comprehensive employer-based carp001 matching service, since it is not well served by traditional regular-route bus service. This service will include the ability to provide real-time carp001 matches and is structured to encourage a mode shift from driving alone to carpooling and also to increase from two to three person car-pools on the Katy HOV lane during the AM peak hour. The system will provide geographic-based information on ridesharing and available bus service to employees.

The hypothesis to be tested is that carpooling will increase when individuals are provided with comprehensive ridematching information, including a way to obtain a match either the same day or the evening before for a trip. It is not envisioned that the provision of current traffic information is as critical for this carp001 component as for the bus component. Thus, while current traffic information will be provided if possible, the main focus will be on the development and testing of the instant rideshare matching program.

This initial instant rideshare matching demonstration will focus on the I-10 corridor, centering on trips between the Addicks park-and-ride lot market area and the Post Oak/Galleria area. Four general types of technologies - telephone-based, television-based, radio-based and videotex-based systems - were initially examined for application in the I-10 Demonstration Project. A number of more specific applications were considered within each of these categories.

Due to the type of system needed to provide the instant rideshare matching service - an interactive program tied into a database - the radio and television-based systems were eliminated from consideration. A set of evaluation criteria were developed by the Project Management Team to assist in rating the different technologies. These were grouped into four general categories -- desired system characteristics, compatibility with other METRO and State

Department of Highways and Public Transportation projects, costs, and potential for private sector involvement. Based on the preliminary evaluation, it was recommended that the instant rideshare matching system be implemented initially with a touch-tone telephone-based system. This could be expanded to a combined touch-tone telephone/Videotex system in the future.

The I-10 Demonstration Project is tentatively scheduled to last four years. A multi-year effort is proposed, since experience suggests that, on successful projects, significant mode shifts continue to occur for at least three years. The first year will focus on development and implementation of the instant rideshare matching service, recruitment of participating employers and employees, and collection of the “before” trend line data. The actual demonstration will occur over a three-year time period. Annual reports will be prepared and will provide the information needed to assess whether the project should be continued. The total cost of the I-10 West Implementation Program is expected to be \$8.4 million.²¹

California Department Of Transportation (Caltrans)

FTA is currently funding the California Department of Transportation (Caltrans) to perform the first two phases of the California Smart Traveler Project, which is a possible four-phase project in which public and private sectors will jointly test an audiotex/videotex-based Advanced Traveler Information System (ATIS) in suburban California called Transportation Resources Information Processing System (TRIPS). “TRIPS will enable both carp001 drivers and riders to use touch-tone telephones, personal computers, videotex terminals, and other devices to obtain more timely and accurate information on which to base local travel decisions. Drivers will be able to find out if their planned routes are experiencing unusual traffic delays or to learn the pros and cons of alternative routes. Riders will be able to find the fastest or least expensive ways to get between any two points by public transportation services at any time of the day or night.

[21] Information on Houston’s “Smart Commuter” demonstration is taken from Katherine F. Turnbull, Houston Smart Commuter IVHS Demonstration Project: Concept Design and Implementation Program, prepared for the Metropolitan Transit Authority of Harris County, Texas State Department of Transportation and FTA, June 1991.

“It is anticipated that TRIPS will eventually be included in local videotex (including audiotex) gateways, which will permit local residents to bank, shop, take courses, send and receive electronic mail, and perform hundreds of other activities without leaving their homes or offices. This also will help reduce local transportation, energy, and environmental problems. Videotex gateways, including TRIPS, also will create a variety of new business, education, recreation, employment, travel, and savings opportunities for local residents.

“Caltrans plans to enter ‘partnership’ arrangements with other public and private organizations to design, develop, test, and market TRIPS. Under these public/private partnership arrangements, the public sector will provide transportation expertise, funding, and assistance in resolving regulatory problems. The private sector will provide management, technical, financial, and marketing resources. This should be an excellent opportunity for companies that are experienced in developing user-friendly computer systems (or services) that enable large numbers of people to retrieve information from remote data bases over the public telephone network. It also should be an excellent opportunity for companies interested in audiotex, videotex, smart cards, voice recognition or vehicle dispatching systems technologies.”²²

As of March 1992, the first phase of the project, which evaluated various test sites and technologies, has been completed. The first phase report describes a California Smart Traveler (CST) System Information Network (CASTINET), which uses audiotex and videotex for carp001 matching services. The second phase, lasting 18 months, will involve software development and implementation planning. The possible third phase involves operational trial and evaluation, and the possible fourth phase involves revision and deployment of the system,

In the first phase, six possible sites were identified.²³ UCLA/Westwood, Pleasanton/San Ramone/Livermore (T&Valley), North City Transportation Management Association (TMA) in San Diego, Sacramento/Roseville, Orange County/Irvine, and Simi Valley. It has been determined that Orange County/Irvine will not be used as a site for this project since they are

[22] Robert Ratcliff and Robert W. Behnke, “Transportation Resources Information Processing System,” white paper, undated.

[23] Robert Ratcliff, California Department of Transportation, Division of New Technology and Research.

conducting their own demonstration with FTA. Details on the rationale for choosing these sites are described in a report prepared for the FTA Office of Technical Assistance and Safety.²⁴

Two sites, UCLA and Pleasanton, will have demonstrations of audiotex-based and/or videotex-based single-trip carp001 services, including both informational and transactional services. Even though these are long-term projects, the first phase of these demonstrations, which will be detailed proposals, should be completed by June 1992. Sacramento will be the site of a real-time rideshare demonstration, the first phase of which should be operational by January 1993. The first phase will be informational, rather than transactional. For this demonstration, existing rideshare software will be evaluated for its potential use (Commuter Transportation Services software, which matches by navigable map, and software used by Sacramento rideshare, which matches by grid, are currently being evaluated). In Ventura/Simi Valley, there will be a pre-trip planning demonstration operational by November 1992.

Bellevue, Washington

The Bellevue TMA is conducting the Bellevue Smart Traveler project, which is “an operational test of innovative ridesharing technology, combining cellular telecommunications, voice mail, and computerized real-time information processing on the carpools and vanpools of Bellevue-Seattle’s public transportation system. These technologies are being engineered and integrated into a new kind of information infrastructure which makes car-pools and vanpools a more effective and attractive mode of mass transportation.”²⁵ The envisioned system would include:

- Major enhancements and additions to the Puget Sound region’s existing ridematching system, in order to let travelers have direct telephone communications with a means for arranging a shared ride on an instant, trip-by-trip basis and
- A traffic information system for ridesharing vehicles which provides them an advantage over single occupant vehicles in moving around congested traffic.

[24] Robert W. Behnke, California Smart Traveler (CST) System, prepared for FTA Office of Technical Assistance and Safety, February 1992.

[25] Denise D. Pieratti, University of Washington, Proposal and Project Status Report regarding “Traffic Information System Research Project,” revised November 29, 1991.

“The initial focus of the Bellevue project is on letting drivers of private vehicles find out about neighbors and co-workers who need a lift to a similar destination to the one that the driver is already planning. Neighbors and co-workers will be defined as inclusively as possible, to include people living within (say) a quarter mile of the driver’s home, or working within the same office complex as she or he does.”²⁶

The Bellevue Smart Traveler Project is nearing completion of pre-test monitoring and evaluation of six car-pools which were given cellular telephones and information on dial-up services. Additional information regarding the status of this project can be found in Section 2.3.

2.1.3 Integrated Fare Media

Integrated fare media are tickets that can be used for all modes, such as a magnetic stripe card that could be used for both bus and subway fares.

State-of-the-Art Summary

There are several North American transit systems that are utilizing integrated fare media that can be used on several modes being operated by different transit operators. Most of the current applications of such technology involve the use of magnetically encoded farecards for both bus and rail modes.

Applications

Oakland, California

The TransLink program has moved forward into an operational test phase. According to the Metropolitan Transportation Commission²⁷ (MTC) in Oakland, California, this test phase began in March and will be completed in April. One bus route is equipped with the TransLink fareboxes, and volunteers will use TransLink magnetic-stripe cards to test the equipment and electronics for combination bus and rail fares. Adjustments to the equipment will be made after

[26] Bellevue TMA, “Overview of Bellevue TMA Mobility Innovations,” December 9, 1991.

[27] Joel Markowitz, Metropolitan Transportation Commission, Oakland, California.

the pre-implementation' testing. It is expected that TransLink will be fully operational by September/October 1992.

The overall TransLink project budget is \$5.8 million, with \$4.3 million funded by Federal sources²⁸ and the remaining \$1.5 million funded by MTC. The on-board part of the project, which was described in last year's report, is under \$2 million. The other, larger part of this project is the development of new vending equipment that will dispense the TransLink ticket in major downtown and suburban locations. Riders will be able to purchase tickets either by credit cards or debit cards. This part of the project is expected to be fully operational in 1993.

As described in last year's report, TransLink is an adaptation of the Bay Area Rapid Transit (BART) magnetic-stripe ticket which contains a stored value. At the entry gate, a code is put on the ticket. At the exit gate, the fare collection equipment looks at the entry code, calculates the fare, and subtracts it from the value on the card. The TransLink concept was to replicate that process for a bus, even though a bus does not have specific locations for system entry and exit. The TransLink ticket, which looks like a BART ticket with a different logo in the center, has two columns - one to record bus values, and one to record rail values. The special equipment that accepts this card is near the farebox (It required a special stanchion so that it would not conflict with wheelchairs.)

By the Fall of 1992, 110 Central Contra Costa Transit Authority buses and about forty-five BART-contracted express buses will be equipped to accept the TransLink ticket. Currently, ten percent of the BART gates cannot accept the TransLink tickets. These gates will be reprogrammed to handle the new ticket. In the future, TransLink will be used for parking payment and for fare payment on other modes, such as the ferry.

Los Angeles, California

The Los Angeles County Transportation Commission project will mirror the TransLink project. A pilot project is planned for November 1992 in which one of the fourteen Southern California Rapid Transit District (SCRTD) bus garages and the Culver City and Foot Hills

[28] The first grant was awarded by FTA in 1988.

Transit companies will use a joint magnetic stripe card, facilitating transfers. This project will involve about three hundred buses. Currently, all twelve local bus companies have their own passes and do not honor others. Like TransLink, this will involve a prepaid ticket without an expiration date. A screen reader in the buses will show fare and stored value left on the card. The cards will be renewable and also will be useable on the Blue Line light rail system.²⁹

2.1.4 Multimodal Trip Reservation and Integrated Billing Systems

Multimodal trip reservations allow the traveler to obtain trip reservations and tickets for a multimodal trip (portal-to-portal) from the initial carrier through inter-line agreements. This would be based on interline ticketing and fare collection agreements by inter-regional carriers, transit and paratransit providers in a metropolitan area.

An integrated billing system is one in which bills for the purchase of fares for all modes are generated from a central source. For instance, if bus, subway and air fares for one trip were purchased by a credit card, the billing would be generated by the credit card company.

State-of-the-Art Summary

As discussed in last year's State-of-the-Art report, multimodal trip reservations and integrated billing systems are not currently in use in North America. However, the concepts have been defined and potential demonstration sites have been evaluated in a report prepared for the FTA Office of Technical Assistance and Safety.³⁰

Applications

The following discussion of the Mobility Manager is taken directly from the report Mobility Management and Market-Oriented Transportation.³¹

[29] Mary R. Kihl, "'Smart Transit' The State of the Art Revisited," January 4, 1992, page 6.

[30] Jeffrey A. Parker and Associates and International Taxicab and Livery Association, Mobility Management and Market-Oriented Local Transportation, prepared for FTA Office of Technical Assistance and Safety, Report No. DOT-T-92-07, March 1991.

[31] Ibid.

Mobility Manager

The Mobility Manager is a mechanism for achieving the integration and coordination of transportation services offered by multiple providers -- public, private for-profit, and private non-profit -- involving a variety of travel modes and multiple sources of funding. This integration is accomplished through electronic technologies, allowing the programmatic integrity of all participants to be preserved, while at the same time automating most of the transactions - financial and otherwise -- which occur in the system. The Mobility Manager's function resembles that of a travel agency and a financial clearinghouse. The Mobility Manager has information on all relevant travel choices and service providers and handles most or all of the financial transactions in the system, aided by software designed for this purpose. Various hardware and software technologies, such as magnetic or electronic fare media, in-vehicle card readers that can communicate with computers, computer-assisted vehicle scheduling and dispatching, and computer database systems are likely to be used in a Mobility Manager system.

The Mobility Manager concept relies heavily on electronic technologies to accomplish the various transportation, informational, and financial transactions that are at the core of the operation of this system. Three technologies are of critical importance to the Mobility Manager concept:

- Computer-assisted or fully automated routing, scheduling, and dispatching of vehicles participating in the system (see Section 3.1.3),
- Electronic fare collection systems (see Section 2.2.3), and
- Computer database systems to record and process all financial and non-financial transactions,

Four locations were identified as potential demonstration sites by Jeffrey A. Parker and Associates and the International Taxicab and Livery Association.³² These locations are Los Angeles; Portland, Oregon; Medford, Oregon; and Pinellas County, Florida. Forums were held in these locations to discuss the details of potential demonstrations of the Mobility Manager

[32] Ibid., pages 28-45.

concept. Currently, FTA is funding Mobility Manager projects in Norfolk, Virginia and in Medford.

Medford, Oregon

In Medford, the Rogue Valley Council of Governments (RVCOG) is developing a Mobility Manager demonstration which will integrate transportation users, providers and funding sources. The first phase of this project will focus on providing transportation to the elderly and disabled who are unable to use fixed route transit. Using existing hardware and readily-developed software, the second phase will demonstrate the Mobility Manager concept for frequent transit riders in urban and rural environments. The third phase will lead to participation by the general public.

RVCOG prepared a timetable for organizing a Technical Advisory Group (TAG), hiring staff, developing the conceptual design, selecting a contractor, conducting marketing and training, evaluating and selecting the technologies to be used, implementing the technologies and evaluating the system.

To date, the TAG has been created (and has met several times), staff has been hired, and the conceptual design for the Mobility Management Project (MMP) has been prepared. RVCOG has issued a request for proposals (RFP) for computer and communications systems technical support. Project elements include:

- Provider and Agency Information Systems,
- Electronic Fare Media,
- Multimodal Trip Reservation,
- Electronic Billing,
- System Information and Reporting Services, and
- Dispatch Services.

The entire MMP is expected to be completed by June 1993.

Trancometer™

An example of a partially integrated “Mobility Manager” system for both regular taxi operations and human service transportation has been in operation in Sweden since 1983. Halda, Inc. has brought the “Trancometer™ In-Vehicle Computer (IVC) technology from Sweden to the U.S. paratransit market.”³³ The Trancometer™ is an electronic unit which features both electronic fare collection and direct interface with a computer database system. This unit can accept the use of magnetic stripe or Smart Cards, allows preprogramming of up to forty fares, and includes digital communication via radio with a central dispatching facility, a thermal printer for producing receipts and hard copies of reports, and a built-in modem which can automatically transfer accumulated data to a central computer. “There are over five thousand Trancometer™ IVCs in use in Sweden in over two hundred systems.”³⁴ Trancometer™ has just become available in the U.S. for use by paratransit operations.

Before describing the Trancometer™'s functions, it is important to note that it can be fully integrated with the Paratransit Management System (PtMS) by Automated Business Solutions (see Section 3.1.3). “Integration with PtMS is in the form of two software modules. The *Service Accounting Module* features integration of data from Trancometer™ System into the PtMS service accounting function. The *Mobile Dispatching Module* integrates the Trancometer™ with the PtMS scheduling and dispatch function.

“For a paratransit system, the Trancometer™ IVC is supplied with three basic functions: passenger processing, vehicle operations, and driver performance and productivity. Data on each of these functions is gathered by the Trancometer™ IVC throughout each shift. This information is then uploaded directly to a computer in order to perform analysis, create custom management reports, and produce Section 15 reports, ADA reports, and other required reports. For paratransit and transit systems which require it, information to verify contractor billing or analyze contractor performance is now more available.”³⁵

[33] Halda, Inc., “TRANCOMETER™,” marketing brochure, p. 1.

[34] Ibid.

[35] Ibid, pp. 1-2.

“There are four ways to transfer data between the host computer and TrancometerTM. Data from the TrancometerTM IVC may be uploaded/downloaded through its built-in modem by connecting the IVC to a phone line. A direct connection can be made similarly from a yard or shop. The TrancometerTM can be brought into the office for upload/download. Lastly, a radio communication link between the TrancometerTM IVC and the host computer for systems with radio communications capability will be available in mid-1992. The radio link permits two-way data communication between the TrancometerTM IVC and the computer.”³⁶

Gandalf Mobile Systems, Inc.

In the United States, Gandalf Mobile Systems Inc. produces Advanced Mobile Data Products³⁷ (AMDP), consisting of hardware and software that provide a communication link between an existing dispatch office computer or information management system and mobile personnel, similar to the Mobility Manager concept. AMDP allows mobile personnel to exchange information with the existing computer system without interrupting normal services. All connections are managed by a Network Communication Controller (NCC). The Mobile Equipment communicates with the computer, via the NCC, over a wireless communication link. Gandalf offers two series of mobile data terminals, both of which are intelligent and micro-processor controlled. These terminals can transmit, receive, and organize messages and provide connections for auxiliary devices such as bar code readers, printers, and magnetic stripe readers.

Gandalf’s “Mobility Manager” system, which utilizes AMDP, is a scheduling and management tool designed for the paratransit industry. It is formed of five progressive modules consisting of automated trip order taking, automated demand-responsive scheduling, automated data collection, dynamic data exchange, and dynamic data and dispatch scheduling.³⁸ The Mobility Manager integrates scheduling, vehicle monitoring, and dispatching functions, in addition to providing system management tools. Gandalf’s Mobility Manager and CABMATE(R) products will be discussed in more detail in Section 3.1.3.

[36] Ibid, p. 5.

[37] Gandalf Mobile Systems Inc., “Advanced Mobile Data Products,” brochure, undated.

[38] Gandalf Mobile Systems Inc., “Mobility Manager Paratransit Scheduling and Management,” brochure, January 20, 1992.

2.2 CUSTOMER INTERFACE

Customer interface provides services to the passengers of a system to make their travel easier. This includes information on arrival times, the general condition of the system, and simplified methods of payment. Each of the strategies is designed to make the user's trip easier, from the point he or she first begins the trip, to his or her arrival at the destination.

System information and automated ticketing are described in this chapter. First, in-terminal information systems are discussed, wherein information is provided to passengers at major transfer points and downtown terminals. This generally consists of the scheduled and/or actual arrival times of each bus. In-vehicle information systems follow. In these, information is provided on-board and enroute, usually consisting of next-stop information and estimated arrival times. The chapter finishes with electronic ticketing and automated trip payment. This is both a labor-saving measure and a means of giving the passenger greater service and flexibility in payment.

2.2.1 In-Terminal Information Systems

In-terminal information systems consist of electronic and computer display devices located at transit stations and/or enroute stops, providing up-to-date travel information on delays, cancellations, reroutings, and terminal layout and services. These systems may involve interactive traveler input and can be designed to accommodate disabled travelers.

The systems vary in complexity from simple closed-circuit television monitors providing scheduled vehicle arrival and departure information to large-format, sensitive map displays combined with sophisticated algorithms to assist travelers to find the best routes to their desired destinations. Specific applications may be linked to automatic vehicle location or vehicle identification systems to provide real-time updates on transit system status.

State-of-the-Art Summary

With the expanded interest in automatic vehicle location systems, the opportunities for expanded traveler information systems are increasing as well. Unfortunately, most transit operators are limiting their view of AVE as simply a tool to increase system efficiency and improve scheduling. Its potential in providing real-time arrival information to travelers has not

yet been widely tested in the United States. Although automatic displays announcing the arrival of the next two or three trains are well established in the areas of light rail and heavy rail, they are not yet a regular feature in bus stations. Similarly, automated displays updating expected times of arrival, like those found in BART stations, are not generally found in U.S. bus stations, much less at major transfer points. Plans are underway to incorporate traveler information systems with some of the new implementations of AVL. Interactive computers which can provide travelers with information on appropriate routes and schedules to reach requested destinations are, however, still more an aspect of the future than of the present for most U.S. transit systems.

Nevertheless, as more systems begin to move beyond stand alone displays and simple schedule display boards, the issue of equipment compatibility will become increasingly significant. The possibilities for incremental additions to AVL are numerous, both in terms of operation and passenger information systems. Transit systems which want to incrementally add display boards, smart kiosks, and on-board informational systems will need to plan ahead so as to insure overall system compatibility. The need for industry-wide standards for equipment associated with smart transit is becoming increasingly apparent.

Applications

Anaheim, California

The City of Anaheim is actively engaged in developing a concept plan for a project which will provide real-time information to travelers at bus stops and transfer stations as well as in transit vehicles. Real-time information on schedule updates will be derived from data supplied by an automatic vehicle locator system and the current Caltrans freeway monitoring system. The central traveller information system in Anaheim will convey information to passengers waiting at key transit stops by using display boards or smartkiosks.³⁹

[39] "Traffic Management Information and Fleet Operations Coordination, " FTA project description.

Baltimore, Maryland

The MTA plans to employ a Traveler Assistance Network in its downtown terminal in connection with its new AVL system. This public information system network will display accurate real-time arrival of a connecting service on monitors located at key transit stops and transfer points. The display can list the arrival times for the next three connecting buses.⁴⁰

Foreign Applications

This type of information is already being provided to passengers in Osnabrueck, Germany and Stockholm, Sweden. Bus stops are equipped with computerized real-time passenger information through a computerized 'mobile' system that supplied the internal 'next stop' announcement on the bus as well as a digital and voice 'next arrival' notice at each sheltered bus stop. The system, manufactured by Init Corporation of Karlsruhe, is currently being phased into the five thousand mile Stockholm municipal bus network.⁴¹ In London, England electronic display boards show the expected time of arrival of the next bus and provide a realistic prediction of the second and third buses' arrival. Information is relayed to the electronic display boards by an AVL signpost system. One route is currently operational and others will be phased in as funding permits.⁴²

Westinghouse Electric Corporation

The Smartkiosk concept, also being developed by Westinghouse, will enable travelers to retrieve information from both static and real-time databases. The static database will provide information on local restaurants, hotels, and points of interest as well as provide basic transit schedule information. The real-time transit data will be directly supplied by a transit operations center. Travelers will not only be able to access the information through interactive computers, but will also be able to obtain a hard copy of requested schedule information for future reference. Tourists will be able to use the static file to find points of interest along with the

[40] Venkata Rao, Mass Transit Administration, Baltimore, Maryland.

[41] Public Innovation Abroad, June 1991.

[42] The Daily Telegraph, July 9, 1991.

real-time information on how to get there. Plans call for multiple uses of the kiosks including automatic teller banking, automatic theater and sports event ticket vending, and refreshment vending.⁴³ These kiosks are to be tested in Cape May, New Jersey; Houston; and Anaheim.

Denver, Colorado

Denver currently has kiosks in the two downtown transit stations along with electronic display systems that list the next three departures. Although these are based on printed schedules rather than real-time data, there is provision for regular updates. Denver, as well as other cities which are planning to test the new GPS AVL, is considering passenger information systems which will be able to interface with the new real-time data base. Unfortunately, the current Prime computers used in the Denver passenger information system are not readily compatible with computers to be used in other aspects of the AVL system. Similar problems with incompatibility are confronting Houston as it moves from its current display terminal to a new city-wide GIS system.⁴⁴

Houston, Texas

Houston has deployed “Digiplan” terminals in three key locations in downtown areas. Tourists are provided with a “cartoon style” map of the city with the bus system superimposed on it. Users touch the screen at their preferred destination and are shown which route to take to that point. They also can push a button to receive a printed version of their directions to take with them. The machine is multilingual and route changes can be input by modem from the central office. The display terminals have been well received by tourists and other members of the public, but are difficult to update with data and hard to integrate with other aspects of the Houston Smart Commuter project because of the nature of the geographic data base. Digiplan is machine-specific since the display map is not drawn to scale and cannot be folded into a city-

[43] Chris Body, Westinghouse Electric Corporation, Electronic Systems Group, Command and Control Divisions, Baltimore, Maryland.

[44] Dan Hulse, Regional Transportation District, Denver, Colorado.

wide GIS system. The cost of the terminals (\$100,000) also has discouraged other operators from acquiring Digiplan .⁴⁵

2.2.2 In-Vehicle Information Systems

In-vehicle information systems consist of technical innovations supporting the transit user and vehicle operator. Travelers are aided by information displays and communication devices providing information on routes, schedules, and connecting services as well as remote telephone and computer connection capabilities. Additional information available to vehicle operators might include displays and communication systems indicating correctable schedule deviations, requirements to wait for connecting services, and on-board mapping and GIS support.

State-of-the-Art Summary

With the passage of the Americans with Disabilities Act (ADA) in 1990 came a new set of requirements that transit operators make their vehicles accessible not only to travelers using wheel chairs, but also to the visually and hearing impaired. The Department of Transportation's requirements issued in October 1991 require that all fixed route transit vehicles provide both visual and audio information to passengers, identifying major intersections and key transfer sites. The expectation was that visually and hearing impaired travelers would then be able to use fixed route transit with confidence.

The area of in-vehicle information systems is certainly one in which increased interest can be expected in the near future. As more fixed route systems move into compliance with ADA requirements, there will be increased interest in not only meeting the legal requirements, but also of taking the opportunity to go further with developing information systems to appeal to all riders. Once the Global Positioning System AVL systems become fully operational, they will introduce other opportunities for informational transfer both to riders and drivers.

[45] Darrel Puckett, Metropolitan Transit Company of Harris County, Houston, Texas.

Applications

DOT's ADA requirements have stimulated new interest in an area which previously had received limited attention: in-vehicle-navigation aids. Major vendors have found greatly expanded markets for products that had previously appeared to be luxuries.

Digital Recorders, Inc.

Digital Recorders, Inc. has responded to the ADA requirement to provide on-board verbal cues with the "TalkingBus," a maintenance-free voice messaging system which announces stops and other necessary information. The system informs passengers, while allowing the driver to concentrate on the road and passenger safety. Subways and other rail systems have long provided automated announcements about approaching stations, but for buses this is a new venture.

The Durham (North Carolina) Area Transit Authority is currently testing the Digital Recorder system on one of its busiest routes. Reaction has been positive. Foothill Transit in the San Gabriel Valley of California plans to have eighteen recorders installed on its buses soon. Salem, Oregon is about to install the same system on its Salem Area Transit. The recorders distributed by the Transit Communications Systems division of Digital Recorders, Inc. require only limited power, but the costs per vehicle are relatively high, \$5,000 to \$7,000, compared to \$500 for a standard public address system.⁴⁶

Luminator

Luminator has introduced a voice annunciator which is activated when the bus door opens, and a message announcing the route number and destination of the bus is broadcasted to passengers waiting at the stop. The volume of the annunciator is adjusted to compensate for background noise and provides messages that are clearly audible in noisy areas and pleasantly audible in quiet areas. Messages also can be bilingual. The system is easily installed and

[46] William Staedeli, Digital Recorders, Inc.

programmed. This system is currently being tested in Dallas, Texas; Long Beach, California; New York City; Washington, D.C.; and Wilmington, Delaware.⁴⁷

For the visually impaired, Luminator is introducing the “MegaMax” large format matrix sign which is double the size of the standard sign. Luminator’s large matrix signs were successfully introduced in Nice, France in 1989 and were formally introduced in the United States at the American Public Transit Association’s Expo in Houston in 1990.

Telcite, Inc.

Telcite Inc.’s Visual Communication Network (VCN) has taken the in-bus automated signage system one step further by providing automated scheduling information as well as providing other types of information to the passengers. Animated color graphics and continuous programming keeps the passengers updated on current news, weather, sports, cultural events, and other items of educational interest. The object is to reduce the passenger’s perception of a long trip and to increase the appeal of using mass transit. The same signs also can serve effectively to provide paid advertisements or public service announcements. When tested in Montreal, eighty-eight percent of the passengers indicated that the presence of VCN enhanced their trip; advertisers were pleased with increased product awareness; and the elderly, hearing and visually impaired were enthusiastic.⁴⁸

Driver Communications

In terms of on-board communication with drivers, the state of the art has not advanced as rapidly. With the expanded interest in automatic vehicle location systems, an increasing number of dispatchers are able to communicate with drivers through a light panel which indicates that the bus is early, late, or on time. However, no other information is regularly shared with drivers. Map navigational devices, which are being tested in automobiles through IVHS studies in Los Angeles and Orlando, have not yet been tested on transit vehicles. The application of mapping and route guidance systems to demand responsive paratransit is apparent.

[47] Barbara Lange, Luminator.

[48] Masahall Moreyre and Frank Ruffolo, Telcite, Inc.

The Ann Arbor Transit Authority tested an on-board navigation system on its paratransit vehicles but is now in the process of replacing its whole AVL system. Other paratransit operations have not yet begun tests of on-board navigation systems.

2.2.3 Electronic Ticketing and Automatic Fare Payment

Electronic ticketing involves the automated generation of tickets and automated fare collection, allowing for the collection of detailed information on revenue, passengers, and origins and destinations.

Automated trip payments are those payments made without a manual exchange of coins or bills. Often, electronic ticketing provides automated trip payment through the use of magnetically encoded farecards or advanced card technology. Advanced card technology typically means plastic cards (credit card size) with a programmable memory chip that can be used for identification, trip payment, and other travel-related functions.

State-of-the-Art Summary

Electronic ticketing and automated trip payment are technologies that are beginning to be utilized in several transit agencies throughout North America. Frequently, these two technologies go hand-in-hand, i.e., electronic ticketing often provides automated trip payment through the use of advanced card technology or the more conventional magnetically encoded (stored-value) cards.

Applications

Chicago, Illinois

The Chicago, Illinois Regional Transportation Authority's (RTA) Payment and Control Information System (PCIS) was discussed in last year's state-of-the-art report. New information is as follows. Phase I of the project, system design and development, is almost complete. Phase II, implementation, will follow when a contract has been signed. Acceptance testing of the Smart Card and associated equipment started in March 1992. A two-week pilot test will be conducted with CDT, one of the Chicago Transit Authority's (CTA's) four Special Services

carriers. (This pilot test is intended to be a mock system operation, with the contractor staff (Applied Systems Institute, Inc.) shadowing drivers in order to ensure proper operations of all the equipment.) For this pilot test, Smart Cards will not be distributed to riders. Rather, the cards will be available in the vehicle, and they will be tested with the Telxon card reader (hand-held) units. Trips made during the pilot test will be logged by the PCIS just as they would be during full operation. At the end of each day, each Telxon unit will be put into a cradle to download data to a local area network. Also, updates will be sent to the Telxon units (i.e., identification of lost cards).

Phase II will include ordering the final version of the equipment. (The pilot test will determine if any of the equipment requires modification.) Full implementation with the first carrier (CDT) will begin in the May/June 1992 time frame. Initially, Smart Cards will be issued to subscription riders (people who ride more than 2 times per week). Subsequently, cards will be issued to general riders. At the same time Smart Cards are being issued to the general riders, the second carrier will be trained.

The PCIS will need to be modified if PACE decides to join the project, since PACE works differently with their contract operators than does CTA. Also, the interface between the CTA reservations system and PCIS would have to be modified. PACE has a different reservation system.

Phoenix, Arizona

Since last year's report on the testing of magnetically-encoded passes on several City of Phoenix Transit System routes, the Bus Card Plus Program has been implemented. The Bus Card Plus Program is a system that allows the use of a magnetic encoded plastic credit card to pay the bus fare. The card reader, located directly on the top of the farebox, is controlled by farebox software, and accepts magnetically encoded information from a standard credit card size pass. The cost of the software modifications was \$1,500 per farebox, and the cost of the card reader addition was \$175 per unit.

“Current software recognizes five basic types of cards:

- Monthly passes - prepaid bus passes,
- Phoenix Transit employee/dependent passes - Transit employee or dependent passes,
- Bus Card Plus - bus credit card,⁴⁹
- Credit/debit cards - standard bank cards, and
- Daily passes - prepaid one-day use passes.

Presently, only the first three types of cards are accepted as valid by the farebox.”

More details regarding the software and hardware related to this system can be found in the “Bus Fare Payment by Credit Card: Phoenix Transit’s Bus Card Plus Program” paper.⁵⁰

“The future of the program is to expand the number of employers in the program. Current users include the employees of Phoenix Transit, the City of Phoenix, and private business. The final step is to open the program to bus ride payment through debit/credit cards. Ultimately, debit cards could substitute for transit system passes for the majority of the using public.”⁵¹

Washington, D. C.

Another potential application of Smart Cards has been suggested for the Washington Metropolitan Area Transit Authority (WMATA). “Congress authorized \$1 million for Metro [WMATA] to study and test advanced fare technology as part of the \$151 billion, six-year highway and mass transit bill approved in November [1991].”⁵² One technology that is being considered is a credit card which is sturdier than the current magnetically-encoded Farecard used

[49] These cards are issued by an employer to its bus riding employees.

[50] Thomas J. Ross, P.E., “Bus Fare Payment by Credit Card: Phoenix Transit’s Bus Card Plus Program,” presented at the Transportation Research Board 71st Annual Meeting, January 12-16, 1992, Washington, DC.

[51] Ibid, page 11.

[52] “Post-Farecard Era Planned: Metro Passengers May Use Credit Cards in Future,” Washington Post, January 16, 1992.

by WMATA's rail system. A credit card also would eliminate the need for bus passengers to have change to pay fares.

"As a first step, transit officials will recommend that the Metro board allow riders to purchase Farecards with credit cards and bank cash cards beginning in July [1992] at selected Metro sales outlets (stations, Metro headquarters, bus garages, mobile sales vans and other places). Riders already can buy Farecards using bank cash cards in automated teller machines located at six rail stations.

"Later, transit officials may recommend installing 'swipe readers' on Farecard machines at stations to allow riders to insert credit cards or bank cash cards to buy Farecards. Next, 'swipe readers' could be installed on the fare gates and fare boxes. In this way, riders would use their credit or bank cash cards to enter and exit rail stations and buses. The reader would determine where the rider boarded and alighted and would charge a credit card or bank account.

"Eventually, the use of Smart Cards is being considered, which would combine several uses into a single card. The potential drawback to the Smart Cards is concern about violating riders' privacy."⁵³

Twin Cities, Minnesota

As part of the Twin Cities Smart Traveler project, the Regional Transit Board (RTB) in St. Paul is investigating the use of Smart Cards for fare payment and electronic billing. RTB is being funded by FTA to design a Smart Card system for their Metro Mobility System which provides service to the disabled.⁵⁴ Currently, they are in the process of releasing a request for proposal, which will lead to the hiring of a contractor. Implementation of this system is expected by late 1992, or early 1993. RTB is investigating the use of contactless Smart Cards. Further information on this project can be found in Section 2.3.

[53] Ibid.

[54] Howard Blin, Regional Transit Board, St. Paul, MN.

Northern Virginia

In the soon to open Virginia Railway Express (VRE) commuter rail system in Northern Virginia, Schlumberger's TVM (Ticket Vending Machine) 2000 will dispense "proof of payment" tickets.⁵⁵ The TVMs take only credit or debit cards. The use of debit cards will be limited to the MOST card (available in the greater DC area), since, by law, CIRRUS and PLUS networks cannot participate in point-of-purchase activities. There will be at least two TVMs per station and more than two if the ridership level warrants.⁵⁶ Tickets also will be available for cash at on- and off-site locations.

VRE will offer tickets-by-mail through an Automated Customer Service System that also can be used to obtain system information. Through this unique system, people can order tickets by speaking their name and address into the phone and entering their credit card number and expiration date. The system then will verify the information, and register the person to receive tickets by mail. The system also has an option to fax requested information about the system to the requester.

Schlumberger has just developed the TVM 5000, a modular ticketing machine that can accept bills, coins, credit cards, and debit cards. The transit rider selects the type of ticket from a keypad, is prompted for the amount due, pays for the ticket(s) (multiple tickets can be purchased at one time), and receives the ticket(s). Through the TVM 5000, a rider also can purchase an upgrade for a monthly or weekly ticket, purchase a ticket from an origin other than the location of the TVM, and/or purchase a transfer.⁵⁷ The first TVM 5000s will be installed in 1992.

Los Angeles, California

The Los Angeles Department of Transportation is performing a Smart Card demonstration very similar to a previous one in Pittsburgh which was described in last year's

[55] Schlumberger has installed more than 25,000 TVMs worldwide with over 6,000 in Paris, more than 1,000 TVMs with the French railways, over 50 TVMs in the Oslo Subway and is in the process of installing 40 TVMs as part of the VRE.

[56] There will be 18 VRE stations. The Manassas Line will have 6 unique stations, the Fredericksburg Line will have 8 unique stations, and the two lines will share 4 additional stations.

[57] Schlumberger Technologies, "TVM5000 Technical Specifications, " pp. 1-3.

APTS state-of-the-art report. The demonstration is a test of Schlumberger's SmartBox and Patron Card "on eight express commuter routes involving forty of the Laidlaw Bus Company buses. Plans call for the card to be sold on the buses for about \$10 to \$15 more than the usual monthly pass, but it will later be available in varying denominations. The value of each trip taken will be subtracted and remaining value stored and recorded. Because the card is operating as a small computer, it will possible to program it for reduced fares as well as for full adult fares. Riders will use the cards as a flash pass when transferring to the downtown shuttle."⁵⁸

The SmartBox functions with four types of Smart Cards: Patron Monthly Passes, Stored Value Cards, a Supervisor Card, and a Driver Card⁵⁹. The monthly pass will allow unlimited travel within valid zones during a particular time period. Stored value cards will have a default number of zones equal to the number of zones usually traveled. "Patrons wishing to travel this 'regular' distance will have their cards automatically validated by the SmartBox. If the patron does not wish to travel the 'regular' route, the patron must inform the driver before inserting the card. The number of zones traveled will be input by the driver at this time."⁶⁰

Ann Arbor, Michigan

The Ann Arbor Transportation Authority (AATA) will develop and implement a test of a radio frequency (RF) Smart Card for transit and parking lot use as part of their FTA-sponsored "Smart Bus" project. A set of evaluation criteria and a set of transferrable specifications will be developed. This project will uncover problem areas in the implementation and use of RF Smart Cards. Once these areas are identified, further research and problem-solving may be conducted to increase the viability of the RF Smart Card within the transit industry. Future activities within the project could include a cost-benefit analysis of smart card systems, identifying capital and operating costs and expected returns, or an evaluation of the hardware and software of optimal systems.

[58] Mary R. Kihl, "'Smart Transit' The State of the Art Revisited," January 4, 1992, page 7.

[59] Schlumberger, "SmartBox Proposal to LADOT," June 22, 1990, page 1 of SmartBox Functional Operations section.

[60] Ibid, Page 2 of the SmartBox Functional Operations section.

Fare Payment Study - GLH, Inc.

FTA is sponsoring a research project which will investigate and research various forms of advanced fare payment media for transit applications. The focus is upon advanced card systems which could improve the efficiency of fare collection and provide measurable benefits to the transit provider and rider alike. There will be in-depth descriptions and analyses of all types of advanced media, including infrared, RF/microwave, contact smart cards, proximity cards, and others. The operating environment for transit fare payment systems will be defined and system requirements specified. In addition, the project will categorize the merits of different advanced fare media, and comment on the future potential for each. The project will address smart card use by bus, rail, paratransit, and integrated transit systems. This work is being performed by GLH, Incorporated.

2.3 THE “SMART TRAVELER”

The “Smart Traveler” is a person who has access to real-time and reliable information in order to make travel decisions that involve high-occupancy vehicles and transit. The concept of the Smart Traveler encompasses several technologies including Smart Cards, audiotex and videotex, telephones, cable television, personal computers, and geographic information systems. The use of one or more of these technologies will facilitate a traveler’s decision to carp001 or take transit.

2.3.1 Description

A basic starting point for the Smart Traveler concept is to ensure that automated information on all public transportation services in the area will be available at a single telephone number. Eventually, riders will call a single telephone number and if their preference is to carpool, they will be immediately assigned a ride. Near term, the arrangement may need to be made the night before or an hour before the trip. Ultimately, matching will be done in real time to a near-by vehicle traveling a similar path. Appropriate fringe parking locations with space to park and to meet a vanpool or carp001 will be given. Drivers will be told their routing with pick-up and drop-off locations via a data link and on-board monitor.

The system would provide much of the flexibility of the private automobile while saving the expense of traveling alone. Adding passengers is an incentive for the drivers, if they want to qualify for use of time-saving HOV facilities. Possibly, some type of credit system for drivers could be included to further encourage participation.

For those considering the transit option, interactive displays on personal computers or television will provide a graphic view of public transportation services. The traveler would address the screen much as a Nintendo game and indicate origin and destination. A graphic display would map out the best route and indicate appropriate bus route numbers and stops.

Even before the interactive display is perfected, cable television subscribers and personal computer users in cities with automatic vehicle location systems will be able to access transit schedules much as they can obtain traffic congestion information, news reports, or stock quotes. Audiotex and/or videotex information could alert passengers to restaurants, shopping, and special event opportunities as they near these locations.

The Smart Traveler also will enjoy the greater use of cashless fare transactions. Exact change should disappear as a requirement to use transit. A number of transit properties are already offering multiple trip tickets with magnetic stripes. These cards are debited for each trip taken; information on fare and location is logged in at the farebox and the rider gets the card back with the cost of the trip deducted from the stored value. Some systems are beginning experiments which allow the traveler to use these cards when transferring to different bus systems or between bus and rail.

Smart cards are the next step in fare card technology. They have already been tested extensively in Europe for pay telephone use and transit applications and will be more readily available in the U.S. soon. Travelers may store cash amounts on the cards, enabling them to use the card not only to pay for transit trips, but also as a single fare media to pay for parking, telephones, toll roads, and bridges. The card may identify client services of social service agencies. The card also could record individual travel data on which to base fare discounts that encourage greater transit use.

In-trip information will be provided by smart kiosks in stations or hotels on well-traveled transit corridors. These kiosks will provide audio, visual, and hard-copy responses to travelers in exchange for advertising space. Variable message signs, similar to those already used in

some transit systems, will show the estimated time of arrival of buses at particular well-traveled locations, especially at transfer points. Audio information will be provided for visually disabled passengers. Several transit operators already use variable message signs along transit malls to indicate the next buses expected at each loading position.

This information enables the operators to use the loading positions efficiently and the riders to locate the appropriate bus effectively. Once on-board the bus, the traveler will be informed by automated audio and visual signs of key cross streets and major transfer points. The real-time arrival of connecting vehicles also will be announced.⁶¹

2.3.2 Field Operational Tests Planned and in Progress

Currently, there are four Smart Traveler projects funded by FTA. The following project summaries describe each project, provide a brief status of the project as of March 1992, and discuss possible future developments.

Bellevue Smart Traveler

This project examines ways in which mobile communications, such as cellular telephones, can be used to make ridesharing (carpooling and vanpooling) more attractive. A set of information-based services for ridematching has engaged the mobile telecommunications industry in an effort to increase the use of HOV facilities. Phase I of the project developed a plan to implement this ridesharing service. Phase II will be an operational test and will include an evaluation. In addition to cellular telephone, the technological applications include voice mail, computer-based ridematching, “smart” ID cards, traffic monitoring computers, and electronic maps. The initial focus will be to advise private auto drivers of rideshare possibilities.

The development of a plan involving both the public and private sectors, for a two-year operational test of mobile communications to improve and expand HOV usage is nearing completion with a report expected by July 1992. The next stage of this project will be an

[61] The preceding description is an excerpt from FTA Administrator Brian Clymer’s presentation entitled “Transit Initiative in IVHS,” presented at the 1992 TRB Annual Meeting.

operational test of a dynamic ride match scheme and the equipping of registered carpools with mobile telecommunications.

California Smart Traveler

As discussed previously, this project supports the efforts of the California DOT to design and operationally test and evaluate the California advanced public transportation systems program for applying IVHS advanced technology to transit, paratransit, and ridesharing. Both the public and private sectors will jointly test an audiotex/videotex-based advanced traveler information system in suburban California. The information system will permit residential and business users to interact over telephone lines to exchange timely transportation information, using remote computer systems.

The first phase of the project evaluated various test sites and technologies. Five sites have been identified for operational design and testing. A draft report has been prepared describing a California Smart Traveler Information Network which uses audiotex and videotex for carp001 matching services. Caltrans has proposed a comprehensive operational test and evaluation which will involve a public-private partnership based upon work accomplished in the Partners for Advanced Transit and Highways program. Future work would include an impact assessment on travel demand and an evaluation of a standard navigable map database.

Houston Smart Traveler

This project works toward the development of a real-time traffic and transit information system. Four tasks are underway:

- Assess the market potential to increase bus, vanpool, and carp001 use by providing traffic information, bus choices, and carp001 options to travelers at home or work;
- Evaluate the various available technologies and identify those most feasible and cost-effective;
- Examine various ways of gathering and distributing transit and traffic information, to include the identification of roles and costs for the agencies involved; and
- Identify the project's administrative requirements and projected costs.

The concept development phase has been completed. The final draft report is being circulated for comment. If found to be feasible, the next phase of the project will be an operational test of the concept with an evaluation and analysis. These activities are being closely coordinated with the IVHS Priority Corridors Program.

Twin Cities Smart Traveler

This project will support the efforts of the Minnesota Department of Transportation, the Metropolitan Transit Commission, and the Regional Transit Board to conclude the design and perform an operational test of the “TravLink” project, which is a part of the Minnesota Guidestar program. These three agencies, together with the FHWA, have established the foundation for TravLink, an automatic vehicle location and traveler information system designed to:

- Provide relevant transit service and traffic data to transit users and ridesharers at home, work, and transit terminals;
- Provide real-time location data for transit vehicle monitoring, fleet management, and coordination with other systems;
- Evaluate the applications of audiotex and videotex systems using real-time data
- Provide travel time savings estimates for HOV use; and
- Alert transit users at transit terminals and parking garages of bus arrival and departure times.

The project has recently been initiated, and system design is currently underway. Efforts from this project could provide a means for expanding TravLink into areas of fare collection and billing,

3. VEHICLE AND SYSTEM-BASED SYSTEMS

Two basic types of Advanced Public Transportation Systems are discussed in this report. Each of these is defined by their basic application and whether they center around transit and rideshare current and prospective *users* (customer-based), or transit and rideshare *vehicles* (vehicle and system-based). These two groups overlap a great deal; consequently, applications in many sites will be discussed in both chapters.

Vehicle and system-based systems center around vehicles (including transit vehicles, paratransit vehicles, carpools, and vanpools) and guideways (including roads and tracks). The technologies, innovations, and applications in this area are those that make HOV options more efficient and productive to the providers and to the users. There are two different types of vehicle and; system-based systems:

- Vehicle Operations and Communications
- High Occupancy Vehicle Facility Operations

Each of these is discussed in this chapter.

3.1 VEHICLE OPERATIONS AND COMMUNICATIONS

Technological innovation in vehicle operations and communications will result in better management of existing fleet resources. In the case of a fleet of transit vehicles, for example, these innovations improve the performance and productivity of the fleet without adding new vehicles. Further, the focus is on innovation, using existing technology in new applications, rather than on invention and giant leaps in technology.

Many innovative vehicle operations and communications applications have been implemented to date, the most innovative of which are described in this chapter. The first is automatic vehicle location, which allows for better fleet control since each vehicle's current position is known and the computer can make a comparisons of the vehicle's current position to where the vehicle should be, assuming it were on schedule. This comparison is greatly facilitated by transit operations software in real-time operation, which is discussed next, The

software also may provide strategies for alleviating schedule deviation and improving operations overall. The discussion of transit operations software is followed by automated demand-responsive dispatching systems and their application. These have great potential to improve the efficiency and effectiveness of this service.

3.1.1 Automatic Vehicle Location

Automatic vehicle location (AVL) is a powerful tool for dispatching and controlling a fleet of vehicles. It is used extensively by transit agencies and trucking companies to control their fleet and to improve on-time performance. An AVL system measures the position of each vehicle and then reports the information to the computer at the dispatch center. The transit operator, with the aid of the computer, may put that information to several uses, which include:

- Real-time corrections to improve on-time performance,
- Planning information for future scheduling and run-cutting, and
- Real-time inputs for passenger information systems.

With additional equipment, the system also can perform the following:

- Automatic recording of ons and offs, using automatic passenger counters,
- Vehicle condition monitoring,
- Emergency (security) alarm, and
- Farebox alarm (theft/pilferage).

A type of AVL system has been in place for many years in rail operations at several transit agencies. Location of light and heavy rail cars is greatly eased, since the guideway is fixed and exclusive to transit vehicles, the vehicles are of uniform dimensions, and vehicle spacing is more controlled than for buses operating in normal traffic. The system can locate vehicles when their wheels pass points where sensors are located. Because of the uniformity of the vehicles and the regulated following distances, there is little danger of counting two trains

as one or one as two, even when multi-car trains are employed, and trains of different lengths are in service simultaneously.

Communications also are greatly facilitated in rail systems, because the infrastructure is already in place along which communication lines may be laid. Because there are rails, and power is supplied to the vehicle from the substation, there are convenient paths for wires and no need for complicated radio systems. Since AVL for rail is not really “new,” and since it can be implemented without sophisticated and innovative technologies, the following discussion will focus exclusively on bus operations.

There are many elements in any AVL system, some of which are essential components for operation, and others which are simply useful additions to the basic system. Many different technologies are available for performing the component functions. The basic components and possible additions are listed first, followed by descriptions of existing systems, in which the technologies chosen for each piece are discussed.

The necessary components for any AVL system include:

- A method of position determination,
- A means of communication with the dispatcher (real-time), and
- A central processor capable of storing and using the transmitted information.

Each of these components was described in detail in the previous state-of-the-art report. All are necessary for the system to perform all of the functions of an AVL system.

In addition to the necessary components listed, a number of additional components can be added to an AVL system that will enhance its capabilities. Each of these also was described in detail in the previous state-of-the-art report.

- Automatic passenger counters
- Engine component monitoring/mechanical alarms
- Signal preference/HOV lane access equipment
- Security alarm
- Connections to passenger information systems

State-of-the-Art Summary

As in the previous state-of-the-art report, automatic vehicle location continues to be tested and implemented extensively by transit agencies throughout the world. Although more widespread in Europe, there are several AVL implementations and tests in progress throughout North America. There is a large amount of variation from city to city in the complexity and the uses of the systems. There is also a large amount of variation in the technologies chosen for the basic components: location, communication, and processing equipment and strategy.

Several North American examples also exist of each of the added features. It is rare for all of them to be present in a single operation. Typically, one or two are used by each agency, and their choice depends on factors specific to the agency and the area.

The agencies which have tested AVL systems generally are pleased with their performance. Although initial problems with new installations are quite common, these problems are typically attributed to the need for fine tuning and calibration. Most agencies report that it is crucial to choose the system that best fits the environment in which the system will operate. This includes the magnitude of the operation and the size, demographics, and weather of the area served. Future plans vary among agencies, but most of those who have implemented or rigorously tested AVL have plans to continue or expand their implementation.

Trends

In general, there is increasing interest in AVL implementation. Nearly all of the implementations noted in last year's state-of-the-art report are still operational, and there are a few new cities in the process of implementation. Few major problems with AVL systems were reported during this investigation. Nearly all of the studies, requests for proposals, and installations have proceeded at a fairly rapid pace.

There has been a significant development in the area of location technology. Civilian satellite systems for object location are now becoming widely available. The most notable, the Global Positioning System (GPS), is the technology chosen for a number of new implementations and tests. This technology has, to a degree, "replaced" LORAN-C (ground-based signal triangulation) for transit applications. There were a few agencies examining or testing LORAN-

C for future implementation. Nearly all of these agencies are now examining GPS instead, although those agencies who were using LORAN-C are still using it.

Few agencies contemplating a new implementation of AVL are considering signposts or a stand-alone dead-reckoning system. GPS with differential can be of comparable accuracy to dead-reckoning and signposts, while adding the ability to track vehicles off-route and even outside the service area. GPS requires less infrastructure than signposts and, therefore, has lower capital costs. GPS allows a transit operator to change its route structure without a change in infrastructure. With a signpost system, signposts would have to be added or moved.

There also has been a significant development in the area of communications. The dearth of available radio frequencies in many U.S. urban areas has presented a problem for many agencies. In many instances, this permits polling rates for AVL systems which are too infrequent for desired accuracy. To solve this problem, a new strategy, called "Exception Reporting," is becoming fairly common. The route structure and schedule are pre-loaded into a memory module on-board the bus. As the "Smart Bus"⁶² proceeds along its route, it compares its current position to its expected position on-board. The bus will communicate its position to central dispatch at regular intervals, if it is still on schedule, and the computer at the dispatch center will estimate the bus' position between reports, assuming it's still on schedule. If the bus deviates from its route or schedule, the bus immediately communicates its true position to dispatch.

Applications

A few systems, chosen to highlight the most innovative systems and to present a representative cross section of the available technologies, are described in detail. Summary information is provided for North American systems in Table 3.1.

[62] The term "Smart Bus" indicates that there is intelligence present on-board the bus.

TABLE 3.1 NORTH AMERICAN AVL SYSTEMS⁶³.

City, State/Province	Vehicles	\$M	Status (as of 3/31/92)	Principal Contractor	Location	Freq.	Poll
Ann Arbor, MI	0/67	0.3	<i>System to be Replaced</i>	General Railway Signal	DR (+4S)		13-14
Baltimore, MD	900/900	11	<i>Soon to Release RFP for Full Implementation</i>	Westinghouse	LC or GPS		20
Champaign-Urbana, IL	69/69		<i>In Regular Use</i>	<i>II Morrow</i>	LC		
Chicago, IL	1900/1900		<i>RFP to be issued</i>			8	
Dallas, TX	844/844		<i>Final Testing</i>	ElectroCom Automation	GPS	9/2	180 *
Denver, CO	833/833	10.4	<i>Currently Under Installation</i>	Westinghouse	GPS	?/2	*
Fort Lauderdale, FL	192/192	2.3	<i>Currently Under Installation</i>	Motorola	SO	2/1	*
Halifax, Nova Scotia	170/170	1.0	<i>In Regular Use</i>	(agency)	SO		30-40
Hamilton, Ontario	275/275	6.0	<i>In Regular Use</i>	RMS Industrial Controls	DR	3/1	30
Houston, TX	1000/1000		<i>Designing/Building System</i>	(agency)	GPS		
Hull, Quebec	162/162		<i>Testing</i>	(various)	SO		
Jacksonville, FL	180/180		<i>RFP Issued in 10/91</i>				
Kansas City, MO	275/275	2.1	<i>In Regular Use</i>	F & M Global	SO	1/1	15-30
Miami, FL	520/520		<i>Evaluating Proposals</i>		GPS		
Milwaukee, WI	550/550		<i>To Begin Installation Soon</i>	Westinghouse	GPS	2	*
New Jersey Transit	1800/1800	30.7	<i>Currently Under Installation</i>	Motorola	SO		*
Norfolk, VA	160/160	2.0	<i>In Regular Use</i>	F & M Global	SO		40
Ottawa, Ontario	40/800		<i>Initial Testing of Alternatives</i>	Amtech	SO		
Palm Beach, FL	74/74	1.2	<i>Currently Under Installation</i>	Motorola	SO / LC	3/1	60
San Antonio, TX	537/537	3.7	<i>In Regular Use / Examining Potential Upgrades</i>	General Railway Signal	SO (GPS?)		60
San Mateo, CA	320/320		<i>Final Testing</i>	Motorola	SO	3/1	
Seattle, WA	1341/1341	17	<i>Installing Equipment</i>	Harris Corporation	SO	2	
Sheboygan, WI	20/33	0.1	<i>In Regular Use</i>	<i>II Morrow</i>	LC	3	10-20
Tampa, FL	172/172	1.6	<i>Installing Equipment</i>	Motorola	SO	3/1	180 *
Toronto, Ontario	2300/2300	38	<i>In Regular Use</i>	Bell Radio	SO	11/31	6

[63] Sources: the agencies; Pekilis, B. and G. Heti, Automatic Vehicle Location and Control Systems for Small and Medium Ontario Transit Properties: Phase I Report (Final), Transportation Technology and Energy Branch, Ontario Ministry of Transportation, January 1992.
Text in italics represents new information since the last state-of-the-art report.

Key:

Vehicles - Number equipped/Number owned

\$M - System cost in millions of \$, when purchased. US Agencies - US\$, Canadian Agencies - Canadian \$.

Location - The location technology: SO - Signposts + Odometer; LC - LORAN-C; *GPS* - Global Positioning System; *DR* - Dead Reckoning + signposts,

Freq. - The number of frequencies dedicated: numbers in the format *a/b*, indicate *a* voice channels and *b* data channels.

Poll - Tie between polls (seconds). * = exception reporting strategy employed.

Ann Arbor, Michigan

The Ann Arbor Transit Authority tested an AVL system purchased from General Railway Signal. The system was based on “dead reckoning” with corrections made by map matching (stored on cassette) and a few signposts. Location information was stored on the bus until it was polled, once every thirteen to fourteen seconds, by central control. The location information was transmitted over two-way radio frequencies in the 900 megahertz region. The system included a full-color video display at dispatch, and a silent emergency alarm. The authority also was planning to use the bus location information in a real-time cable TV passenger information system.

The AVL system was recently abandoned, however. The system was not sufficiently accurate and there were a few software problems. The agency is now investigating a GPS system.⁶⁴

Norfolk, Virginia

The Tidewater Transportation District Commission (TTDC) of Norfolk, Virginia installed an AVL system acquired from F & M Global. The system is signpost/odometer-based: the bus maintains a record of its own position until polled, once every forty seconds, at which time it transmits the information over dedicated radio frequencies. The system includes three mechanical “alarms”: low air pressure (brakes), engine temperature, and oil pressure, and also includes an emergency alarm for the driver to activate if he or she is in danger. The system has been operational for about a year-and-a-half. It has been operating well so far, save for a few minor problems, including two failed signposts (only a small fraction of the total number in place). TTDC is currently examining some software modifications/improvements, including a screen display for the dispatcher.⁶⁵

[64] Mike Bolton, Ann Arbor Transit Authority, Ann Arbor, Michigan.

[65] M. L. Sheldon, Tidewater Transit District Commission, Norfolk, Virginia.

San Antonio, Texas

VIA Metropolitan Transit also has a signpost/odometer based system, acquired from General Railway Signal, which is similar to the one in Norfolk. Polling is once per minute. The system also includes mechanical alarms and a security alarm.

This system was implemented over several years and passed final acceptance over three years ago. The Transportation Institute of the Texas A&M University System is currently conducting an appraisal of this system, as well as other AVL implementations in Texas.⁶⁶ VIA is currently examining several potential upgrades to the system, including switching from signposts to a GPS-based location system. VIA's reasoning is that GPS eliminates the need for signpost maintenance and allows for greater accuracy and flexibility. With signposts, changes in route structure may require the addition or relocation of individual signposts.^{67,68,69,70}

Toronto, Ontario, Canada

'The Toronto Transit Commission (TTC) runs a very large operation, containing 2,300 buses and streetcars, in addition to several subway lines. They have implemented an signpost/odometer-based AVL system acquired in 1988 from Bell Radio (now called National Mobile Radio Communication Inc.). The system operates in a manner similar to Norfolk and San Antonio, except that buses are polled much more frequently: once every six seconds. The data is sent via one of thirty-one radio channels reserved for data transmission.

TTC also has an extensive implementation of automatic passenger counters (APCs), which are not fully integrated with the AVL system. The APCs use the same signposts as the AVL, but the count information is not transmitted in real time, and only 150 of the 1,500 buses (800 of the 2,300 vehicles are streetcars) are equipped with APCs. APC information is only

[66] Katherine Tumbull, Texas Transportation Institute, Texas A&M University System.

[67] O'Neil, Jerry, "VIA Looks to the Future with AVM System," METRO Magazine, May/June, 1989, pp. 36,38,39.

[68] "On-Time Performance Improves: VIA Installs New Technology," Passenger Transport, January 30, 1989, p. 7.

[69] "TransitMaster: Fleet Management, Communication, and Control System," a General Railway Signal Promotional Pamphlet.

[70] Dennis Perkinson, VIA Metropolitan Transit, San Antonio Texas.

used for planning and scheduling purposes, not for real-time operations, so the agency only samples each route.⁷¹

Thus far, the system in Toronto is functioning quite well, and TTC reported no major problems or complaints.⁷²

Chicago, Illinois

The Chicago Transit Authority, which operates 1,900 buses carrying 1.5 million passengers during the peak period, is about to issue an RFP for an extensive AVL system. Location referencing will be either by signposts or inductive loop detectors, and data transmission will be over eight reserved radio channels. This low number of available frequencies will require “exception reporting, ” as it was described above. The driver will have a display of on-time performance, and the dispatcher will have the option of computer-aided service restoration. They also intend “connection protection,” the holding of a bus to preserve timed transfers.

The system also will incorporate a number of other features. Traffic Signal preferential treatment will be provided for buses which are running late. A silent alarm for emergency situations will be included, separate from the regular location system. Each bus will be equipped with a transmitter linked to a cellular telephone, and when activated by the driver, police can locate the bus simply by tracking the signal.

APCs will be included, and the information transmitted in real-time. It is expected, however, that these will not be the extensive treadle-mat or infrared beam counters, capable of measuring and recording ons and offs at each stop. Rather, they will work by measuring pressure on the axles and thus, the overall weight of the bus. This will give a gross overall measure of the current load on each bus. This information can be used to supplement passenger information, as well as real-time operational control.

[71] John Panyan and Chris Seewald, Toronto Transit Commission, Toronto, Ontario, Canada.

[72] Joe O’Connell, Toronto Transit Commission, Toronto, Ontario, Canada.

Real-time passenger information also will be available at monitors installed at 250 bus stops.^{73,74}

Baltimore, Maryland

The Mass Transit Administration (MTA) in Baltimore has completed a test of an AVL system acquired from Westinghouse Electric Corporation. The test included fifty of MTA's nine hundred fixed route buses and four supervisory vehicles. Location referencing was by LORAN-C, supplemented by the bus odometer readings and map matching. Data was transmitted over dedicated radio frequencies, with a polling rate of twenty seconds. The system included a digital map for real-time operational control using computer-aided dispatch. The digital map gives a color display of the location of each bus, bus stop, time point, and landmark on the urban street network. Each bus is colored by status: on-time, early, late, off-route, needs maintenance, or has an emergency. The dispatch software permits enlargements of areas of interest and has recording and printing capability.

MTA is about to release an RFP for implementation system-wide. It is likely that the implementation will use GPS, rather than LORAN-C, for location technology.^{75,76} It is also possible that the system-wide implementation will include passenger information systems and traffic signal preferential treatment. The implementation in Baltimore is one of the four evaluations of AVL to be funded by FTA as part of the APTS Program and conducted by the Research and Special Programs Administration/Volpe National Transportation Systems Center (RSPA/Volpe Center).

Denver, Colorado

The Regional Transportation District (RTD) is another of the four AVL sites to be evaluated by FTA and the RSPA/Volpe Center. RTD has recently contracted with Westinghouse

[73] Ronald J. Baker, Chicago Transit Authority, Chicago, Illinois.

[74] Dave Phillips, Chicago Transit Authority, Chicago, Illinois.

[75] Patel, Rohit H., "A Primer on MTA's Automatic Vehicle Location (AVL) System", Mass Transit Administration, Baltimore, Maryland, January 1991.

[76] Rohit H. Patel, Mass Transit Administration, Baltimore, Maryland.

Electric Corporation to supply a GPS-based system for 833 buses and sixty-six supervisory vehicles. Odometer readings will be used as a supplement in areas where the satellite signals are not available.

Communication of data will be on an “exception reporting” basis.” Since only two radio frequencies are available for data transmission, polling on a frequent basis is impossible. Thus, the bus will have a module of route and schedule information on-board, to which it will compare the current time and position. The buses will report only about every two minutes, as long as they keep to the route and schedule. The displays at the dispatch center will be updated more frequently than every two minutes, based on estimates of where the bus is supposed to be. When the bus does deviate from schedule, its true position is automatically reported at the first opportunity. Each signal from a bus will be given a rating of importance, and the most important signal will get through first.

Each dispatcher will have two computer screens, very similar to the system in Baltimore. One screen will contain a map of the city (or a portion thereof), which shows the position of all vehicles being tracked. The vehicles will be color-coded, based on their status: on-time, early, late, off-route, or emergency. The dispatcher will have voice and data (digital messages on an on-board one-line display) communication with the bus.

The dispatcher’s other screen will contain a host of other information, including all “incidents. ” An incident is any situation for which communication between the dispatcher and a bus driver need take place. This can be a false call, a mechanical problem, or a serious emergency which threatens the safety of the driver. Currently, these incidents are manually logged. With the new system, each dispatcher will be able to respond to and log each incident by pressing a few buttons. Further, the incidents and their responses will be transmitted automatically to the RTD’s main computer.

RTD has departure time boards at each of two bus terminals in downtown Denver, which require manual input of schedule changes. With the new computer network connections, these can be made automatically from the agency’s headquarters.

[77] Exception reporting is possible only when the bus has on-board intelligence (is a “Smart Bus”).

Although the primary purpose of the AVL system is to provide for more efficient scheduling and operations, it will include other features. The system will input real-time vehicle position information to the agency's existing passenger information systems, including a phone-in itinerary service and departure time displays at the bus terminals. Currently, these passenger information systems provide only schedule data. Interactive kiosks also will be purchased if funding becomes available.

An emergency alarm will be part of the system. It will include a listen-in feature, a lock-out of communication to the bus, and a change in the bus' status on the dispatcher's display. The system also will include a farebox alarm for instant notification of attempted pilferage or theft of farebox revenues.

RTD also is discussing the feasibility of providing traffic signal preferential treatment for buses with the City of Denver and the Colorado Department of Transportation.⁷⁸

Milwaukee, Wisconsin

The Milwaukee County Transit System has just purchased an AVL system from Westinghouse Electric Corporation. Vehicle location will be by GPS (with an odometer supplement for areas where the GPS signal is not received), and data communication will be accomplished in much the same way as in Denver. The agency expects to use the system primarily for improving schedule adherence and reliability, for better planning and schedule making, and for security. The initial system does not include vehicle condition monitoring or automatic passenger counting, but can be upgraded to include both. Installation of the system will begin shortly, and testing is expected to begin in July 1992.⁷⁹ This implementation is another of the four evaluations of AVL to be funded by FTA.

Dallas, Texas

The Dallas Area Rapid Transit system has just purchased a system from ElectroCom Automation L.P. A total of 844 buses, 216 over-the-road coaches, 245 demand-responsive vans,

[78] Lou Ha, Regional Transportation District, Denver, Colorado.

[79] Ron Rutkowski, Milwaukee County Transit System, Milwaukee, Wisconsin.

two hundred supervisory vehicles, and one hundred transit police vehicles will be equipped. Location will be determined by GPS, and data will be transmitted to the control center over two dedicated radio frequencies. Each dispatcher will have a full console, and each driver will have a display. Without intelligence on the bus, performance-to-schedule will be determined at the control center. The system also will include an emergency alarm and component monitoring.” This implementation is one of the four evaluations of AVL to be funded by FTA as part of the APTS program.

3.1.2 Transit Operations Software

Transit operations software is software that performs and integrates the following functions:

- Network and operations planning,
- Vehicle and crew scheduling and dispatching (commonly called computer-aided dispatching (CAD),
- Marketing, and
- Management and administration.

Individual programs for any of these functions, such as the Run Cutting and Scheduling System (RUCUS) and HASTUS, are not discussed in this section. Only real-time integrated operations software is included.

State-of-the-Art Summary

Many computer software packages have been developed to address each individual aspect of transit operations and planning mentioned above. However, there are few software packages available today that integrate these functions into a comprehensive transit operations automation system that works in real-time. As stated in last year’s APTS state-of-the-art report, there are

[80] “Integrated Radio System, ” RFP issued by Dallas Area Rapid Transit, Dallas, Texas, Jan. 10, 1991.

currently no known real-time operations software systems operating in North America. Last year's report described some systems operational in Europe.

Applications

Boston, Massachusetts

An example of a partially automated monitoring system has been installed at the Massachusetts Bay Transportation Authority (MBTA). This system allows "MBTA personnel to immediately monitor delays and problems, adjust train flow when necessary, and make announcements to passengers so they know when the next train is due.

"Using a system of sensors at twenty-nine locations across the MBTA's Red, Blue, Orange, and Green lines, information is relayed on train movement. Scheduled train times are automatically compared to actual times. Information is updated every twelve seconds. If actual times differ from scheduled times by more than two minutes, controllers at the MBTA's control center are alerted automatically. With this information, announcers can inform passengers at stations. The system also provides valuable information to dispatchers and emergency response personnel about service problems, where trains are located, and where trains are needed, so that subway cars can be rerouted. The system (named the "Passenger Waiting Time System" -- PWTS) has three principal components corresponding to the three audiences the system intends to support: dispatching and control, transportation management, and planning and evaluation. "[8]

Advanced Vehicle Monitoring and Communications

An example of real-time operations software potential is that associated with advanced vehicle monitoring and communications (AVM/C) systems. These systems usually consist of "an automatic vehicle location subsystem, a communication subsystem providing two-way voice or data connections between the drivers and dispatcher(s), a data processing and computational subsystem to assist the dispatcher, and an automatic passenger counting or load monitoring

[81] "New Computerized Train Monitoring System in Boston to Reduce Passenger Waiting Time, " The Urban Transportation Monitor, March 1, 1991, pp. 4 and 16.

subsystem."⁸² Operations can be directly controlled and monitored by such a system, either with human interaction or with software. Most operational AVM/C systems do not utilize real-time operations control software. Rather, dispatchers and other related personnel use real-time information provided by the AVM/C to perform operational modifications (often referred to as CAD). This can be considered real-time operations control, even though it is not accomplished by software.

Toronto, Ontario, Canada

One example of such an AVM/C system, a real-time control system called Communications and Information System, is currently being used on the entire surface fleet of the Toronto Transit Commission. "For each division, a central computer is connected to sampling on-vehicle mini-computers and to three dispatcher consoles. Each dispatcher console has specialized keyboards and can issue data commands as well as conventional voice radio or text. The driver interface consists of a rugged dashboard mounted unit that contains a voice/data radio, a microcomputer, with standardized keyboard, and display. This display shows the time and current schedule deviation, if any, along with any text messages. The driver interface unit is called TRUMP, for Transit Universal MicroProcessor. There are numerous peripheral devices, including a speaker that is connected to the dispatcher's office. The location technology is of the microwave radio signpost variety, combined with an odometer."⁸³

3.1.3 Automated Demand-Responsive Dispatching Systems

Automated demand-responsive dispatching systems include scheduling features which assign individuals to demand-responsive transit vehicles that are operating in a shared-ride mode. The scheduling systems would accommodate advanced reservation trips, standing orders, and immediate (or real-time) requests. Immediate trip orders (dispatching) would be accommodated from base to mobile with on-board digital displays or on-board hard copy printouts. Information

[82] Edward K. Morlok, et al, Advanced Vehicle Monitoring and Communication Systems for Bus Transit: Benefits and Economic Feasibility, prepared for FTA University Research & Training Program, Final Report, September 1991, UMTA-PA-1 I-003.5-91-1, page 1.

[83] Ibid, page 18.

from scheduling and dispatching functions would be integrated into the management information, billing, and accounting functions of the provider.

State-of-the-Art Summary

Advanced technology has been applied to the scheduling and dispatching of demand-responsive vehicles through the use of computers and advanced communications. More and more paratransit systems are fully automating their scheduling, dispatch, billing, and accounting functions by using systems that contain such advanced technologies as geographic information systems, two-way mobile data communications, smart cards, CAD, and automatic vehicle location systems. Updating the information obtained for last year's APTS state-of-the-art report revealed that the automated dispatch industry is rapidly becoming more sophisticated in terms of technology such as data communications. In several of the new examples presented in this section, "data dispatching" is being used as part of paratransit scheduling and dispatching systems. CAD is an integral part of all the examples presented in this section.

Applications

It should be noted that there are many automated scheduling and dispatching systems available.⁸⁴ However, not all of them have been successfully implemented. It is important for prospective clients of these types of systems to carefully evaluate any software and/or hardware product in terms of accommodating their specific needs and having a proven track record with other similar clients.

Automated Dispatch Services, Inc.

The EMTRACKTM system developed by Automated Dispatch Services, Inc. (ADS), which was discussed in last year's state-of-the-art report, has been updated to include payroll, logging operations and monitoring productivity.⁸⁵ ADS has tripled their paratransit business using this system since last year.

[84] This set of examples is not an exhaustive list of available automated dispatching and scheduling systems.

[85] David Brown, Automated Dispatch Services, Inc.

The system basically operates in the same manner as described in last year's report. However, there have been several functions added. EMTRACKTM's basic functions are as follows:⁸⁶

- Order Entry Workstation - provides the means to enter the trip request information required to dispatch the call. Various features of this function include:
 - Screen Configurability
 - Address Verification
 - Patient Recall
 - Pre-Scheduled Trips and Reservations
 - Rolodex Selection
 - Other Features:
 - Remote-connect
 - Context-sensitive help for each field
 - Transaction recall
 - Round trip transactions
- Dispatch Workstation - allows a dispatcher to take the calls entered by the order entry station(s) and efficiently assign the most appropriate vehicles. The dispatcher is aided by a graphic representation of the service area which displays calls and vehicle fleets. Various features of this function include:
 - Screen Display
 - Vehicle Locating and Routing
 - Vehicle Tracking
 - Transaction Tracking
 - Candidate Vehicle Selection
 - Graphic Display
 - Information Accessibility
- Mobile Digital Communications - supersedes voice communications. Information that was entered at order entry and assigned to a vehicle at dispatch can be made available to the driver of the vehicle via an on-board terminal.
- Batch Routing and Scheduling - takes basic routing parameters entered by the user and feeds the calls entered into call taking. The system will then generate the most optimal routes and automatically feeds them to the dispatch station.

[86] "EMTRACKTM Series 2.0 Functional Spec, ' Automated Dispatch Services., Inc.

- * Operations Management - can generate reports containing statistics about the calls that have been run. Various reports are available, including Demand Analysis, Exception Report, Dispatch Log, No Transport, Origin-Destination, and Reconciliation.

Gandalf Mobile Systems, Inc.

In addition to the Motorola system that was described in last year's state-of-the-art report, other equally sophisticated products are being used for paratransit scheduling and dispatching. One of these products is called Mobility Manager and has been developed by Gandalf Mobile Systems, Inc. (GMSI). Mobility Manager is a demand-responsive scheduling and dispatch system, which "consists of five progressive modules beginning with automated trip order taking and scheduling, and culminating with dynamic data dispatch and scheduling."⁸⁷ These five modules are as follows:

- Mobility Automated Scheduler (MAS) - provides client registration, automated trip entry system, automated trip scheduling under user-specified operating parameters and objectives, a computerized street directory, real-time travel calculations, driver manifests, and customized agency billing reports.
- Mobility Demand Responsive Scheduler (MDRS) - provides real-time scheduling by automatically matching a trip request with the proper route in real-time at call entry. If there is a same-day change, the updated schedule is immediately relayed to the driver using either voice or mobile data communications. These features are part of MDRS: real-time adjustments to scheduled routes, automatic reassignment of unserved trips due to vehicle breakdown, and special handling of trips with uncertain return times.
- Mobility Automated Data Collection (MADC) - is an independent module that can automate ridership data collection through individually issued client Smart Cards, in-vehicle electronic card readers, in-vehicle automatic data collection, and a remote download of data to the dispatch center.
- Mobility Real-time Data Exchange (MRDE) - links MDRS with MADC. It uses mobile data communications to provide real-time vehicle monitoring and dispatching. Its features include: in-vehicle mobile data terminal (MDT), radio frequency (RF) modem and interface to the Smart Card reader, real-time data collection at dispatch center, real-time updating of actual route status, automatic reassignment of trips if the vehicle is delayed, and instantaneous exchange of accurate route information between MDT and MRDE.

[87] Gandalf Mobile Systems Inc., "Mobility Manager" product literature, January 20, 1992.

- ‘Mobility Dynamic Scheduler (MDS) - provides data dispatching of short-term schedule information and extensive re-optimization of routes in light of same-day changes. MDS eliminates the fixed driver manifest by using the MDT to download an abbreviated schedule to the driver.

Mobility Manager is being installed in several locations in the United States. In addition to Mobility Manager, GMSI offers other products that utilize data communications. These are the CABMATE^(R) Computerized Taxi Dispatch System, which currently has twenty customers in the U.S. (installed in 6,360 vehicles) and eight customers in Canada (installed in 2,705 vehicles); Network Control Processor developed for the Telesat Mobile Inc. RoadKIT^(R) mobile data service (being installed in 750 vehicles); Computer Aided Voice Dispatching (CAVD), which is in the process of being installed in 985 vehicles in London and Minneapolis; and Fleet Management Business System (FBMS), a fully-integrated fleet management and business control system incorporating software used in CABMATE^(R) Computerized Taxi Dispatch Systems and in the Network Control Processor.

Micro Dynamics Corporation

Another computerized dispatch system for demand-responsive transportation is CADMOS (Computer Assisted Dispatch Management Operations System) PRO+. This system, developed by Micro Dynamics Corporation, is a real-time dispatching system that provides the following management functions:⁸⁸

- Reservation/Call Management: includes client tracking, pickup and destination address street management, automatic street zoning and bad address tracking, trip type and trip purpose assignments, automatic or manual vehicle assignment, charge account and credit card number tracking.
- Pre-Scheduled Reservations: includes trip scheduling in advance, printing of weekly/daily schedule, trip type and purpose tracking, and trip mileage, travel time, and wait time tracking.

[88] Micro Dynamics Corporation, “CADMOS Pro + Highlights, ’ undated.

- Dispatch Management: includes real-time demand-response and prescheduled “batch” dispatching, driver log in/out with vehicle mileages, vehicle repair requests, and manual override of computer assignments. Also, operational features of this function include: dual-screen dispatch, “instant” graphical street mapping, mobile display terminal, and vehicle locators (LORAN or GPS).
- Trip Management: includes fare, co-payment, and surcharge amounts; cash, charge, and combination payment trips; user-definable trip types; and optional automatic assignment of vehicles.
- Client (Customer) Management: includes tracking of customer name, address, and trip information, user-definable account numbers, and “Trip Prescription” authorization tracking.
- Contract Management: includes contract billing information tracking, group and individual contracts, and rider manifests for group contracts.
- Street Management: includes map book cross-referencing street zoning: day/night and alternate zones, location and address substitution, optional automatic assignment of vehicles by zone, and optional geo-coordinate tracking (LORAN or GPS).
- Vehicle Management: includes tracking of vehicle information including license and permit numbers with expiration, and tracking of equipment usage.
- Driver Management: includes tracking of license and permit numbers with expiration, and drug test information.
- Management Reports: includes over forty-six different reports. Reports can be printed while system is in operation.

Automated Business Solutions

Paratransit Management and Scheduling (PtMS) from Automated Business Solutions “provides paratransit providers, brokers, and system coordinators with the management tools to accomplish day to day operations and management functions including:

- Coordination of multiple funding sources,
- Provider and broker system operation,
- Scheduling and routing demand response and subscriptions trips,
- Real-time dispatching,
- Client registration and (ADA) certification tracking,

- Transaction accounting,
- Agency and client billing,
- Performance monitoring, and
- User-defined reporting,

PtMS is currently installed at seventy-five sites. It can schedule over one thousand trips per day and its transaction accounting system will maintain a trip history of all trip transactions for a client. Some PtMS users are billing and reporting on over 300,000 trips per year. PtMS is fully menu-driven and can be set up by a user with no prior computer experience to fit the requirements of any local system for coordination of multiple funding sources, billing, point to point measurement, client eligibility, trip purpose, and tracking fleet characteristics and performance.

PtMS is fully integrated with the Trancometer In-Vehicle Paratransit Computer developed by Halda. The Trancometer is as small as a car stereo with integrated display terminal, keypad, printer, radio and telephone modems, and card reader. Function keys allow the driver to record all data associated with vehicle activities and passengers. With card reader capabilities, there is virtually no limit to the amount of information transferable between magnetic stripe cards and the Trancometer system, from identification of clients to fares, billing rates, and sponsoring agencies. Mobile dispatch features are also available.⁸⁹ Over five thousand Trancometers are installed throughout Sweden.

Also, PtMS can be linked with an area map, scheduled trips, and drivers through the use of geographical coding. Electronic map data, including the U.S. Census Topologically Integrated Geographic Encoding and Referencing (TIGER) data, can be integrated with any available map system into a street and zone file system. Once read by PtMS, the map coordinates are displayed and then printed on driver manifest reports. PtMS can locate the origin and destination zone for new trips and calculate travel time and distance for scheduling, reporting, and billing.

[89] PtMS literature provided by Stephen G. Pellegrini, President, Automated Business Solutions.

PtMS has add-on products, including the Central Client System registration module, a brokering' module, and a graphical map module that uses the Street Smart system to display an area map with scheduled trips for routing purposes and to determine the %-mile corridor mandated by the Americans with Disabilities Act. Street Smart also can print directions for the driver.

Mobile Computer Systems, Inc.

Mobile Computer Systems, a sister company to Metro Transportation in Philadelphia, is beginning to offer real-time dispatching by radio or mobile terminals. Their system is integrated with MapInfo, a computerized mapping program. Currently, the system is being integrated with a routing and scheduling package called Route Smart. Mobile Computer Systems is hoping to begin to serve the shared-ride/paratransit market.”

Kustom Electronics

Another computerized dispatch system, which includes mobile data communications, is being used by taxi companies. It was developed by Kustom Electronics, and contains computerized dispatching through call-taker, mobile data communications and system management functions. This computerized taxi dispatch system probably has applications in the paratransit industry.

Automated Dispatching Study - University of North Carolina

The Institute for Transportation Research and Education at the University of North Carolina has prepared a draft report which assesses computer dispatching technology in the paratransit industry. This report includes an assessment of several automated dispatching systems, including Gandalf and Motorola which are discussed in this report.

[90] Eric Stern, Mobile Computer Systems, Inc.

Portland, Oregon

The Tri-County Metropolitan Transportation District of Oregon (Tri-Met) is still planning on having a fully automated scheduling system, as was described in the last APTS state-of-the-art report.⁹¹ Currently, they are expecting to have the address geocoding data for this system by Summer 1992. Tri-Met will use the local metropolitan planning organization's (MPO) geographic information system to determine the %-mile corridor for ADA, and will be developing a trip planning system for their fixed-route service that will interface directly with the GIS. Also, Tri-Met's paratransit scheduling system will be upgraded to interface with the MPO's minicomputer.

3.2 HOV FACILITY OPERATIONS

High occupancy vehicle facility operations includes those technologies designed to improve the flow of HOVs by giving preference to these vehicles or by constructing special guideways to control their movement. In the first case, they give preference to HOVs, including buses, vanpools, and car-pools, who share the right-of-way with conventional traffic. In the second case, special guideways are constructed to control the HOV's lateral and/or longitudinal movements, thereby reducing headways and required lane widths because vehicle control is increased.

Several different types of HOV facility operations are discussed below. Each is first defined by its general concept, and then further described through specific examples of past, current, or future applications. A number of strategies are discussed. These include preferential treatment for buses at traffic signals at urban intersections, strategies for enforcement of occupancy restrictions in HOV lanes, and automated guidance for transit buses.

3.2.1 Traffic Signal Preferential Treatment

Traffic signals are usually timed so that each movement through the intersection is given green time proportional to the number of cars which want to make that movement. In addition, a series of signals at intersections along arterial streets often will be timed in concert so that a

[91] Park Woodworth, Tri-County Metropolitan Transportation District of Oregon, Portland, Oregon.

platoon of vehicles travelling at or near the speed limit will arrive at each intersection when the light is green. This strategy maximizes the throughput of vehicles at each intersection, and along the street.

To maximize mobility, however, is to maximize the throughput of *people* along a street. If HOVs are given preferential treatment at traffic signals (also called signal preemption), the throughput of people will be increased, and the maximum number of people will benefit. Further, the decrease in delay at intersections will encourage travelers to choose the higher occupancy transit option.

Preferential treatment for buses at traffic signals must be considered as part of an overall system. Signal preemption, whether an extension of the green phase or a shortening of the red phase, should be based on the schedule adherence of the buses. Buses running late would be eligible for preference, but no preemption would be effected for those on or ahead of schedule. In this way, schedule adherence would be maintained, and disruption to regular traffic flow would be minimized.

Once the eligible bus is identified, the preferential treatment is effected, in accordance with the specified control strategy. The control strategy defines the conditions and the duration of the preemption. This can range from unconditional on both, to only a limited extension during certain parts of the cycle. The equipment and strategy can be implemented as an extension to the standard control equipment for the signal.

State-of-the-Art Summary

As described in the previous state-of-the-art report, there are still some difficulties in the implementation of preferential treatment for buses. It has been argued that this strategy disrupts traffic flow. Many traffic professionals have found that signal coordination and progression are more effective tools on heavily traveled arterials than preemption. There is also the problem of giving preference to buses in mixed flow traffic, especially under congested conditions. The bus tends to remain stuck in traffic, unless other vehicles are allowed to clear the approach. Finally, coordination between traffic and transit agencies is essential but often difficult. Nevertheless, a few of the newer automatic vehicle location system implementations are planning to include preferential treatment.

Applications

As reported in the previous state-of-the-art report, a few cities do have preemption for their light rail lines. These include the Southeastern Pennsylvania Transportation Authority in Philadelphia, Pennsylvania, the Santa Clara County Transit District in San Jose, California, and the Southern California Rapid Transit District in the Los Angeles area.

A few transit agencies are considering preferential treatment for buses in conjunction with automatic vehicle location systems they are currently planning or implementing (see Section 3.1.1.) . The two reported in the previous state-of-the-art report, the Chicago Transit Authority and Broward County Division of Mass Transit in Fort Lauderdale, Florida remain planned applications. In each case, the bus would be located and identified by the AVL system, which would then apprise the traffic signal. Both of these implementations are still in the early planning stages, so control strategies have not been discussed in great detail. CTA has indicated that preferential treatment, if implemented, would be only for those buses running behind schedule. ^{92,93}

3.2.2 High Occupancy Vehicle Lane Control

High occupancy vehicle lanes have been established for several years in many U.S. cities as a means of encouraging motorists to carp001 or take the bus. These have been very effective for better utilization of the existing highway network. Sometimes, however, those carrying less than the specified number of passengers use the HOV lanes, and diminish their utility to rightful users. In an effort to reduce the rate of violators, the lanes often are patrolled by police who manually count the number of people in each vehicle as it travels the HOV lane. While this is an effective method of identifying violators, it is manpower intensive and therefore expensive.

APTS potentially has the capability to reduce the number of violators using the facilities, through two distinct strategies. The first of these is to restrict access to the lanes by means of a barrier which would open to allow rightful users to pass and remain closed to potential violators (HOV access control). The other strategy is to use cameras and image processing

[92] Ronald J. Baker, Chicago Transit Authority, Chicago, Illinois.

[93] Glenn Margolis, Broward County Division of Mass Transit, Ft. Lauderdale, Florida.

technology to count the number of passengers in each vehicle and to report violators automatically (HOV lane enforcement). Both of these strategies were discussed in the previous state-of-the-art report.

There have been no regular installations of these strategies. A test of HOV lane enforcement in the Seattle, Washington area was discontinued. The technology employed was not capable of automatically determining vehicle occupancy for many vehicles. Consequently, it was necessary to rely heavily on manual viewing of tapes, a process which proved to be too expensive and time-consuming. The method was replaced with manual observers using lap-top computers.^{94,95,96}

Another test of HOV lane enforcement was conducted in California by Systan, Inc. In the experiment, three video cameras were placed at different angles at the same location, adjacent to the HOV lane. A police officer was stationed in a vehicle about two thousand feet downstream. If there was a detection of an apparent violation through the video cameras, the police officer was immediately notified and asked to check it out. It was determined that the cameras provided relatively accurate detection, although probably not accurate enough to stand up in court.^{97,98}

3.2.3 Automatically Guided Transit Buses

Guided bus technology has not changed significantly since last year's APTS state-of-the-art report. However, there is more information available on currently operating systems. To review, there are two types of guided bus systems - track guidance and electronic guidance. Track guidance is where "the bus is mechanically directed by physical contact with guidrails

[94] Rutherford, G. Scott et al, HOV Compliance Monitoring and Evaluation of the Hero Hotline Program, Transportation Northwest, Department of Civil Engineering, University of Washington, Seattle, WA, February 1990, pp. 54-65.

[95] Mark Hallenbeck, University of Washington, Seattle, Washington,

[96] Ron Colusa, California Department of Transportation, Los Angeles, California.

[97] Billheimer, John K., Ken Kayler, Charles Shade, Use of Videotape in HOV Lane Surveillance and Enforcement: Final Report, Systan, Inc. in association with ATD, Inc., performed for the State of California Department of Transportation under contract 55 G710, March 1990.

[98] John Billheimer, Systan, Inc., Los Altos, California.

at the edges or in the center of the track. “⁹⁹ There are two types of track guidance - controlled guidance and fixed guidance¹⁰⁰.

Electronic guidance consists of “a cable buried in the road, which emits a signal that is collected by a transducer on the bus to actuate the steering system. It is considerably more expensive to equip and modify the vehicle than for other systems, although track costs are lower as the cable can be easily installed in a normal roadway. Such systems have been extensively tested by the Transport and Road Research Laboratory in the U.K. and by several bus manufacturers, There has been one demonstration project in public service (Furth, Germany), but no systems are in revenue service. “¹⁰¹

Furth, Germany

In Furth, the demonstration of electronic guidance began in 1984. The route was 1.5 kilometers and had three stops. Three buses serviced the route at a high frequency. The demonstration was discontinued “in December 1985, when the Nuremburg underground railway was extended to Furth. The project successfully demonstrated the operation of electronic track guidance. “¹⁰²

Rochefort, Belgium

A controlled track guidance system is in operation in Rochefort, Belgium. In this system, “centrally-located bogeys are fitted directly under each bus axle and linked to the wheel-steering mechanism. Each bogey incorporates front and rear arms with steel rollers which, when lowered, engage a central rail, providing guidance. Thus, there are no side curbs, only a central rail which can be inset into the road surface.

[99] M.J. Read, et al, “The potential for guided busways,” *Traffic Engineering & Control*, Volume 3 1, number 11, November 1990, p. 580.

[100] Fixed guidance can be further defined as either mechanical guidance, in which only the front wheels of the bus are directed by the track, or forced guidance, in which all wheels of the bus are directed by the track.

[101] M. J. Read et al, p. 580.

[102] Ibid, P. 584.

“In May 1988, Guided Light Transit (GLT) was introduced into revenue operation in Rochefort. The route is 15 km long. From the station to city center (4 km) a disused railway right-of-way, including a tunnel and two bridges, is used to locate a one-way track with overhead catenary, providing a test of guided electrically-powered operation. In 1990, this system operated with two vehicles at very low frequencies - six departures and six arrivals per day at the station. “¹⁰³

Essen, Germany

The most common guided bus technology is mechanical track guidance, which is operating in Essen, Germany and Adelaide, Australia. An operational test of this technology was performed in West Midlands, U.K., a suburb of Birmingham. In Essen, the 0-Bahn system of mechanical guidance was adopted (see last year’s APTS state-of-the-art report). “The project was implemented in stages starting in 1980 and resulted in mixed operation of light rail transit (LRT) and guided buses on at-grade alignments and in tunnel in 1988. This included conversion to guided bus operation of a 4 km stretch of former tramway, located on the median strip of a motorway and an existing tunnel under the city center. By 1988, buses had covered 2.5 million km of guided operation, without significant operational problems and without serious defects with either the track or guidance equipment.”“

Adelaide, Australia

In Adelaide, “the 12-km guided busway connects the city center with the north-east suburbs of Paradise and the regional center of Tea Tree Plaza, along a corridor following the River Torrens Valley. The first 6-km section to Paradise opened in March 1986, and the extension to Tea Tree Plaza was completed in July 1989. There are only three busway stations, allowing buses to make the best use of their exclusive right-of-way. Stations are off-track, enabling the operation of a high-frequency service without the need for all buses to stop at each stop and permitting the running of non-stop express services between the city center and Tea

[103] Ibid, pp. 581 and 584.

[104] Ibid, pp. 581 and 582.

Tree Plaza. During the peak, buses from thirteen routes, at typical headways of ten to twenty minutes, join the guideway at the three stops having ‘trawled’ the suburbs to pick up passengers. Along the guideway, very high frequencies are achieved, and passengers boarding at busway stations experience one bus every seventy-six seconds on the inner sector of the busway.”¹⁰⁵

Birmingham, United Kingdom

In Birmingham, a six hundred meter track was built in 1984 to test the 0-Bahn concept. The unique part of this operation was the use of double-deck buses. Even though the test was successful, the project was terminated in January 1987 due to objections from local residents about the destruction of the land where the track was constructed.

Partners for Advanced Transit and Highways - University of California, Berkeley

As part of the Partners for Advanced Transit and Highways (PATH) program, longitudinal and lateral control systems for all types of vehicles have been investigated¹⁰⁶. Guidance on a single lane, median lanes, or an HOV facility was investigated. The potential for traffic operations and safety aspects of lateral and longitudinal control systems in HOV facilities was documented in a report. PATH is currently looking at vehicle-autonomous longitudinal control systems. Within a year, there may be vehicle fleets that adopt longitudinal systems (e.g., early warning collision systems). Currently, there are no large-scale longitudinal control systems in operation in the U.S.

3.3 THE “SMART VEHICLE”

The “Smart Vehicle” is another of the concepts included in the APTS program. It incorporates many of the vehicle-based APTS technologies and innovations for more effective vehicle and fleet planning, scheduling, and operations. The technologies and innovations involved in this concept include those enumerated below, many of which were described earlier in this chapter.

[105] *Ibid.*

[106] Ted Chaval, Institute of Transportation Studies, University of California, Berkeley, California.

- Automatic Vehicle Location
 - Automatic Passenger Counters
 - On-board Passenger Information (Voice and Visual)
 - Voice Communication from Driver to Passenger
 - Driver Information Display
 - Silent Alarm
 - Vehicle Diagnostics
 - Farebox, Including Smart Card Reader
 - Signal Preemption Requesting Hardware and Software
- Automated Demand-Responsive Dispatching Systems (On-board Equipment)
- 0 Transponders for Automatic Toll Collection and HOV Verification
- On-Board Automatic Guidance Equipment

The Smart Vehicle concept does not require all of these features to be present in each application or implementation. Rather, some sub-set of these will be present, depending on the environment in which the specific application is employed and the needs of the service providers and users in the area. For ease of discussion, the Smart Vehicle will be described with all the above features, when described in general.

3.3.1 Description

The Smart Vehicle is the IVHS answer to the basic need for an efficient, reliable, safe transit system. Both voice and data communications would be available between the bus and central control. The vehicle would have the capability of traffic signal preferential treatment at intersections and would be equipped with automatic passenger counters and smart card readers. The vehicle also would have two sets of variable message signs: one which would display route information to awaiting passengers at pick-up locations, and another which would give stop information to passengers already on-board. The vehicle's operating performance would be monitored from the garage by sensors placed throughout the engine compartment. Finally, a silent alarm would be available to the driver for security purposes.

One of the most consistent public frustrations with bus systems is their perceived, and sometimes actual, lack of schedule reliability. Patrons aren't sure whether the bus is late or whether they just missed the bus and have a twenty to thirty minute wait for the next one. Research has shown that this uncertainty more than doubles perceived wait times. Advanced displays showing arrival information will be available in the dispatch center, the home, and major boarding areas. These displays will provide passengers with real-time service information, eliminating the uncertainty of when the bus will arrive.

Another inconvenience to transit passengers is the frequent need to pay fares in exact change, or purchase a pass for an entire month (or other period of time), regardless of the expected level of transit usage during that period. As described in the "Smart Traveler" concept in the previous chapter, the Smart Card has the ability to provide to users greater ease of payment and more payment options and to the agency, greater flexibility in fare structures. Smart Card readers on-board the vehicle are the Smart Vehicle application of this concept.

Vehicle tracking systems and other components of the Smart Vehicle concept can produce data useful for management purposes. The data automatically being collected on system performance may be used for planning schedule improvements. The data also hold considerable promise for increased operational efficiency and schedule adherence. Early action can avoid bunching of buses that causes large service gaps and also can prevent schedule delays that lead to missed transfers. Audiotex or videotex instructions can alert the driver of paratransit or flexibly routed vehicles of unexpected detours, real-time congestion information, and requests for route deviation in low demand periods and areas.

Sensors on the vehicle will automatically monitor such things as passenger loading, the engine, and other equipment. This can be used to supplement system performance data both for future planning and scheduling and for operational control. The system's monitoring of the engine and other equipment will make dispatchers immediately aware of bus problems and malfunctions. They can quickly advise the driver of corrective actions or dispatch a replacement vehicle.¹⁰⁷

[107] The preceding description is an excerpt from FTA Administrator Brian Clymer's presentation, "Transit Initiatives in IVHS," presented at the 1992 TRB Annual Meeting.

3.3.2 Field Operational Tests Planned and in Progress

Currently, there are five Smart Vehicle projects being funded by FTA. The following project summaries describe each project, provide a brief status as of March 1992, and discuss possible future developments.

Ann Arbor Smart Vehicle

The Ann Arbor Transit Authority (AATA) will develop and implement a test of an RF Smart Card for transit and parking lot use. A set of evaluation criteria and a set of transferrable specifications will be developed. Three possible options are also being considered:

- A button on the card would activate an alarm at a bus stop or parking lot and act as a personal security device;
- A continuous real-time monitoring of the number of vacant spaces in parking lots for traveler information; and
- Better customer usage information to improve parking and transit management.

In this project, the AATA is working with the city of Ann Arbor and the University of Michigan. The city and the university own and manage nearly all paid parking in central Ann Arbor.

The initial phase, a \$130,000 evaluation project of the Smart Cards, is currently underway. This project will uncover problem areas in the implementation and use of RF Smart Cards. Once these areas are identified, further research and problem solving may be conducted to increase the viability of the RF Smart Card within the transit industry. Future activities within the project could include a cost-benefit analysis of Smart Card systems, identifying capital and operating costs and expected returns, or an evaluation of the hardware and software of optimal systems.

CTA Smart Vehicle

This project will identify automatic vehicle location and bus traffic signal preferential treatment technologies and analyze their impact on traffic and bus operations in a Chicago

transportation corridor. Based on data from an earlier study, which investigated selected IVHS hardware and software products and specifications, the project will examine innovative bus service improvements, including AVL and computer-driven dispatch techniques. Real-time information systems, which can be provided to travelers both at wayside and on-board the vehicle, will be investigated. An international search to locate suppliers able to demonstrate actual working systems is included. The project also will involve the preparation of an implementation plan for an operational test.

This \$90,000 Federal - \$50,000 local cooperative agreement was initiated in March 1991. An extensive review of hardware and software vendors has been conducted along with a review of AVL and traffic signal preemption specifications. European cities with AVL systems were examined to identify problems encountered and lessons learned. Once suitable technologies are found, the next phase in this project will be an operational test, followed by an analysis and evaluation of the system.

Portland Smart Vehicle

This project reviews the German-designed Flexible Operation Command and Control System (FOCCS) that integrates fixed-route transit, dial-a-ride minibus, and contract taxi services. The information integration provides arrival and destination information to travelers and operators. The review includes the following:

- An evaluation of the technical and economic feasibility of adding audiotex/videotex components and carp001 matching capabilities to the system;
- An evaluation of the technical requirements of adding a FOCCS component to T&Met's central control plans;
- An evaluation of the cost-effectiveness of FOCCS in Portland's rapidly growing suburbs; and
- A design for an operational test for those components found suitable.

This \$90,000 cooperative agreement is funded by \$54,000 in Federal funds and \$36,000 in local funding.

The investigation of FOCCS has been completed and evaluation is currently underway with a draft report expected during March 1992. The next probable phase of the project is to identify and acquire the necessary hardware and software, implement the operational test of the selected components, and follow-up with analysis and evaluation.

Denver Smart Vehicle

RTD is installing an automatic vehicle location (AVL) system, as part of an upgraded communications system, to provide bus location information to transit dispatchers to increase efficiency, ridership, and passenger safety. Location information is supplied by the global positioning system (GPS), which uses a series of navigation satellites. The location of each bus is determined by a GPS receiver on the bus and is transmitted to a central dispatch center. Off-schedule buses are identified so corrective action can be taken to reroute buses when needed.

A contract has been issued for the upgraded communications and AVL system. The system will be installed in the Regional Transportation District's (RTD) fleet of 833 buses and 66 supervisory vehicles. Map displays showing each vehicle's location will permit the dispatcher to control the buses and their schedules. In the event of an on-bus emergency, the driver can summon help through a silent alarm that identifies the bus and its location so the police can be directed to the bus. The cost of the advanced communications and location system is estimated to be \$10.4 million. An evaluation of the system is being initiated by the FTA in close cooperation with the RTD. The FTA and RTD are considering future expansions that can include passenger information and interactive displays.

Baltimore Smart Vehicle

The Mass Transit Administration (MTA) has installed an automatic vehicle location (AVL) system that provides bus status information to the public while simultaneously improving schedule adherence and labor productivity. Fifty buses have been equipped with LORAN-C receivers and 800 MHz radios. The buses' location is determined by the receiver and the information is transmitted to a central dispatch center. Off-schedule buses are identified so that corrective action can be taken.

Phases I & II, an initial deployment of the system to determine its potential, are in operation with fifty buses, four cars, two consoles with a map display. The system involves route independent tracking and driver feedback.

In Phase III, an advanced location technology utilizing the global positioning system (GPS) will be installed. The information on bus schedule adherence and arrival times may be disseminated to passengers through interactive display in homes and offices and customer kiosks (see the "Smart Traveler" concept). Through the Smart Vehicle concept, computer-aided dispatch and AVL for the bus fleet and light rail system (thirty-five vehicles) may be tested. Using bus location and schedule adherence information, late buses can be granted preferential treatment at traffic signals to help them get back on schedule. Each of these potential improvements will be evaluated in the APTS program with close cooperation with the MTA.

4. FTA-SPONSORED FIELD OPERATIONAL TESTS AND RESEARCH

Testing in a real-world environment is essential for a complete and proper evaluation of any technology, system, or innovation. It is only in this environment that the system will be subjected to the challenges that it will experience in regular operation. As part of the Advanced Public Transportation Systems Program, the Federal Transit Administration (FTA) is sponsoring several Field Operational Tests (FOT) of various innovative technologies throughout the country. These tests will include a full assessment of each promising technology with test results widely disseminated. This will allow service providers interested in implementing APTS technologies and innovations to benefit from the FOT information generated by others. It should reduce trial-and-error inefficiencies and may eliminate wasteful implementation of systems that are inappropriate.

Representative Projects

There are several FTA-sponsored FOTs planned or in progress. They are listed in Table 4.1. Further details regarding many of the projects, including status and findings-to-date, are given earlier in this report. More information also is available from the appropriate FTA or local contact.

Table 4.1
Current FTA-Sponsored APTS Field Operational Tests and Research¹⁰⁸

Title, Project #	FTA Contact	Local Agency	Local Contact	Concept
Bellevue Smart Traveler WA-06-0039	Ron Boenau (202) 366-0195	Municipality of Metropolitan Seattle Seattle, Washington	Cathy Blumenthal (206) 453-0644	Smart Traveler
California Smart Traveler CA-06-0242	Ron Fisher (202) 366-4995	California Department of Transportation Sacramento, California	Bob Ratcliff (916) 323-2644	Smart Traveler
Houston Smart Traveler TX-06-0072	Denis Symes (202) 366-0242	Metropolitan Transit Authority of Harris County Houston, Texas	Steve Albert (713) 739-4078	Smart Traveler
Twin Cities Smart Traveler MN-06-0023	Sean Ricketson (202) 366-6678	Regional Transit Board St. Paul, Minnesota	Howard Blin (612) 292-8789	Smart Traveler
Ann Arbor Smart Bus MI-06-0052	Sean Ricketson (202) 366-6678	Ann Arbor Transit Authority Ann Arbor, Michigan	Michael Bolton (313) 973-6500	Smart Vehicle
Portland Smart Bus OR-06-0013	Ron Boenau (202) 366-0195	Tri-County Metropolitan Transportation District Portland, Oregon	Park Woodworth (503) 238-4879	Smart Vehicle
CTA Smart Bus IL-06-0088	Sean Ricketson (202) 366-6678	Chicago Transit Authority Chicago, Illinois	Jim Blanchard (312) 245-9170	Smart Vehicle
RTD (Denver) Smart Bus CO-26-0000	Denis Symes (202) 366-0242	Regional Transportation District Denver, Colorado	Lou Ha (303) 299-6265	Smart Vehicle
MTA (Baltimore) Smart Bus MD-26-0000	Denis Symes (202) 366-0242	Mass Transit Administration Baltimore, Maryland	Venkat Rao (410) 433-4088	Smart Vehicle
Norfolk Mobility Manager VA-03-4501	Helen Tann (202) 366-0207	Tidewater Transportation District Commission Norfolk, Virginia	Carol Russell (804) 627-9291	Mobility Manager
Rogue Valley Mobility Manager OR-03-4500	Ron Boenau (202) 366-0195	Rogue Valley Council of Governments Central Point, Oregon	Gary Shaff (503) 664-6674	Mobility Manager

[108] Based on information provided by FTA, Office of Technical Assistance and Safety.

Table 4.1 (continued)
Current FTA-Sponsored Field Operational Tests and Research

Title, Project #	FTA Contact	Local Agency	Local Contact	Concept
Mobility Manager Development MD-03-0138 and MD-03-0139	Helen Tann (202) 366-0207	International Taxicab Association Kensington, Maryland	Alfred La Gasse (301) 946-5700	Mobility Manager
Anaheim IVHS Operational Test CA-0870 12	Ron Boenau (202) 366-0195	City of Anaheim, Public Works Department Anaheim, California	Donald Dey (714) 254-5183	
Advanced Fare Payment Media MA-06-0209	Sean Ricketson (202) 366-6678	GLH, Incorporated Falls Church, Virginia	Frank Haendler (703) 534-0183	
Transit Network Route Decision Aid MI-06-0052	Sean Ricketson (202) 366-6678	University of Michigan Ann Arbor, Michigan	Chip White (313) 763-1332	
Dallas AVL Test	Denis Symes (202) 366-0242	Dallas Area Rapid Transit Dallas, Texas	Paul Ledwitz (214) 6586663	AVL Test
Milwaukee AVL Test	Denis Symes (202) 366-0242	Milwaukee County Transit System Milwaukee, Wisconsin	Ron Rutkowski (414) 278-4888	AVL Test

APPENDIX: LIST OF CONTACTS

Organization	Contact	Phone #
University of California Berkeley, California	Ted Chaval	(5 10) 642-3559
Halda, Inc. Irvine, California	Roger Teal (in Connecticut)	(203) 656-3458
Systan, Inc. Los Altos, California	John W. Billheimer	(415) 941-3311
California Department of Transportation Los Angeles, California	Ron Colusa	(2 13) 620-3264
Commuter Transportation Services Los Angeles, California	Bob Kohl	(213) 380-7750
Megadyne Information Systems Los Angeles, California	Robert Chapman - President	(213) 452-1677
Bay Area Rapid Transit District Oakland, California	Robert Hueng	(5 10) 464-7784
Metropolitan Transportation Commission Oakland, California	Joel Markowitz, Manager, Advanced Systems	(5 10) 464-7760
California Department of Transportation Sacramento, California	Robert Ratcliff, Research Manager, Multimodal Operations	(9 16) 323-2644
San Mateo County Transit San Mateo, California	John Griffith Danny Ours	(415) 340-6414
Regional Transportation District Denver, Colorado	Lou Ha, Project Manager	(303) 2996265
Cellnet Corporation Stamford, Connecticut	Alex Hyman	(203) 3596333
Association for Commuter Transportation Washington, District of Columbia	Mark Wright	(202) 223-9669

APPENDIX: LIST OF CONTACTS (continued)

Organization	Contact	Phone #
Washington National Airport Washington, District of Columbia	Todd Yankee	(703) 685-8022
Broward County Division of Mass Transit Fort Lauderdale, Florida	Glen Margolis	(305) 357-8391
Jacksonville Transportation Authority Jacksonville, Florida	Joseph Mistrot	(904) 630-3153
Automated Dispatch Services, Inc. Miami, Florida	David Brown, Development Manager John Shermyen	(305) 471-0442 (305) 471-0441
Metro Taxi Miami, Florida	Sigmond Zilber	(305) 944-4422
Metropolitan Dade County Transportation Authority Miami, Florida	Louis Revas	(305) 375-3203
Hillsborough Area Regional Transportation Authority Tampa, Florida	Steve Roberts	(8 13) 623-5835
Palm Beach County Transportation Authority West Palm Beach, Florida	Jerry Bryan	(407) 686-4558
Communications Electronics Specialties, Inc. Winter Park, Florida	Walt Corrigan, Sales	(407) 679-9440
Modeling Systems, Inc. Atlanta, Georgia	Geoffrey Blin	(404) 876-9977 (800) 476-9977
Champaign-Urbana Mass Transit District Champaign/Urbana, Illinois	Robert Patton - Senior Planner	(217) 384-8188
Chicago Transit Authority Chicago, Illinois	Dave Phillips, Program Manager Ronald J. Baker	(312) 664-7200 x3070 (312) 664-7200 x3070
Regional Transportation Authority Chicago, Illinois	Alan Kruse - Senior Analyst Rich Mizera, Director PCIS, PRT Projects	(312) 9 17-0768 (3 12) 917-0799

APPENDIX: LIST OF CONTACTS (continued)

Organization	Contact	Phone #
Vapor Chicago, Illinois	Helen Parejko, Marketing Manager Robert Munson, Advertising Manager	(312) 631-9200 (708) 967-8300
Motorola C&E, Inc. Schaumburg, Illinois	Jeffrey Templeton	(708) 576-7222
Micro Dynamics Corporation Evansville, Indiana	Robert Earhardt, Software Development	(812) 477-3090
Kustom Electronics, Inc. Overland Park, Kansas	Richard Paschall, Director, Can. & Int'l Sales	(913) 339-6767
Mass Transit Administration of Maryland Baltimore, Maryland	Venkat Rao	(410) 333-4088
Westinghouse, Mass Transit Vehicle Management System Baltimore, Maryland	Chris Body	(410) 765-8329
SmartRoute Systems Cambridge, Massachusetts	John Liebesney - President	(617) 494-5160
AM Arbor Transportation Authority AM Arbor, Michigan	Michael Bolton - General Manager	(313) 973-6500
University of Michigan/Transportation Research Institute AM Arbor, Michigan	Robert Ervin	(313) 936-1066
Regional Transportation Board St. Paul, Minnesota	Howard Blin	(612) 292-8789
Kansas City Area Transportation Authority Kansas City, Missouri	Steve Billings	(816) 346-0216
New Jersey Transit New Jersey	Mark Revis	(201) 491-7277
Long Island Railroad New York City, New York	Al Kanazaro	(718) 990-7622

APPENDIX: LIST OF CONTACTS (continued)

Organization	Contact	Phone #
Gandalf Mobile Systems, Inc. Raleigh, North Carolina	Greg Davis, Senior Account Representative	(919) 787 9801
Institute for Transportation Research and Education Raleigh, North Carolina	Gorman Gilbert, Director	(9 19) 878-8080
Digital Recorders, Inc. Research Triangle Park, North Carolina	Bill Staedeli, Transit Communications	(919) 361-2155
Aegis Transportation Information Systems, Inc. Portland, Oregon	Robert Behnke	(503) 2454257
Portland TRI-MET Portland, Oregon	Park Woodworth - Director of Paratransit Svc. Ken Turner	(503) 2384879 (503) 238-49 18
Mobile Computer Systems, Inc. Jenkintown, Pennsylvania	Eric Stern	(800) 338-6066
Automated Business Solutions Media, Pennsylvania	Stephan Pellegrini, President	(2 15) 436-8700
Texas Transportation Institute, Texas A&M University System College Station, Texas	Katherine Turnbull	(409) 845-1535
Dallas Area Rapid Transit Dallas, Texas	Paul Ledwitz	(2 14) 658-6663
MicroCard Technologies Dallas, Texas	John Taskett, VP, Technology	(2 14) 770-5503
Metropolitan Transit Company of Harris County Houston, Texas	Darrel Puckett	(7 13) 739-6093
Luminator Plano, Texas	Barbara Lange	(214) 424-6511
VIA Metropolitan Transit San Antonio, Texas	Dermis Perkinson	(5 12) 227-537 1

APPENDIX: LIST OF CONTACTS (continued)

Organization	Contact	Phone #
Dulles Area Travel Information System Virginia Department of Transportation	Stacy Marlbert, Public Affairs Office	(703) 934-7350
Northern Virginia Transportation Commission Virginia Railway Express	Cameron Muhick, Supervisor, Ticket Vending	(703) 524-3322
Schlumberger Technologies, Parking & Transit Systems Chesapeake, Virginia	Donald Herman, TVM Program Manager Bertrand Moritz - Sales Manager	(800) 523-2 114 (804) 523-2178
Tidewater Transportation District Commission Norfolk, Virginia	M. L. Sheldon - Scheduling	(804) 627-929 1
Tidewater Consultants, Inc. Virginia Beach, Virginia	Andi Overton	(804) 497-895 1
Bellevue Transportation Management Association Bellevue, Washington	Cathy Blumenthal, Executive Director	(206) 453-0644
METRO - Municipality of Metropolitan Seattle Seattle, Washington	Lonny Sewell	(206) 684- 1692
University of Washington Seattle, Washington	Mark Hallenbeck	(206) 543-626 1
Milwaukee County Transit System Milwaukee, Wisconsin	Ron Rutkowski, Program Manager	(414) 278-4888
Sheboygen Transit System Sheboygen, Wisconsin	Ray Ann Brunette	(414) 459-3281
BC Transit Victoria, British Columbia, CANADA	Ron Drolet	(604) 385-255 1
Oracle Communications British Columbia, CANADA	Doug Spaeth	(604) 437-7000
Metropolitan Authority, Metro Transit Division Dartmouth, Nova Scotia, CANADA	Kenny Silver - Transportation Planner Moss Mombourquette - Operations	(902) 421-8571 (902) 42 1-2647

APPENDIX: LIST OF CONTACTS (continued)

Organization	Contact	Phone #
Hamilton Street Railway Hamilton, Ontario, CANADA	Kevin Smith	(416) 528-4200
UMA Engineering Mississauga, Ontario, CANADA	Fran Feadelet, Marketing Manager, Transportation	(416) 238-0007
Ottawa-Carleton Regional Transit Commission Ottawa, Ontario, CANADA	Peter van der Kloot - Director of MIS Joel Kaufman	(613) 741-6440 x321 (613) 741-6440
Toronto Transit Commission Toronto, Ontario, CANADA	Joe O'Connell	(416) 393-4373
TeleRide Sage Toronto, Ontario, CANADA	Doug Baxter, Teletrans	(416) 596-1940
Comm. de transp. de la Communauté régionale de l'Outaouais Hull, Quebec, CANADA	Sallah Barj	(819) 770-7900
Telcite, Inc. Point Claire, Quebec, CANADA	Marshall Moreyre Frank Ruffolo	514-695-7517