CHAPTER 6
Transit-Management Systems

The Advanced Public Transportation Systems (APTS) is a Federal Transit Administration sponsored program to encourage development and implementation of innovative technologies and strategies to improve public transportation and ridership. APTS is an integral part of the ITS initiative and allows for the integration of highway and public transportation intelligent transportation systems to take full advantage of the existing transportation infrastructure. APTS incorporates state-of-the-art computer, telecommunications, and navigational technologies to improve the service and safety of public transportation. Most recent FTA reports categorize the APTS according to four sets of services/ technologies: Fleet Management, Traveler Information, Electronic Fare Payment, and Transportation Demand Management. Not all of these categories and services will be discussed in this handbook, but operational strategies and technologies related to congestion management are discussed in this chapter.

Transit management supports fleet management capabilities by monitoring both the location and performance of vehicles. Transit vehicles equipped with Automatic Vehicle Location (AVL) technology provide the basis for vehicle tracking. AVL provides information regarding the real-time position of a vehicle that may be used to monitor schedule adherence and provide travelers with information concerning the location of transit vehicles. Providing accurate information concerning the status and location of transit vehicles to travelers may improve customer satisfaction and increase ridership.

Location information provided to dispatchers can be used to conduct advanced demand-responsive computer-aided routing and scheduling and may be used to manage fleet resources in response to events that impact schedule adherence. Information describing the current location of a transit vehicle is transmitted to a centralized dispatcher, who then compares the actual location with the scheduled location. Depending on the variance between the actual and scheduled locations, actions may be taken to improve schedule adherence and to transfer information to travelers.

Transit vehicles equipped with Automatic Vehicle Identification (AVI) technology can request traffic-signal priority along signalized routes to improve transit route running times. AVI-equipped transit vehicles can also serve as probe vehicles to prove real-time data concerning the performance of the roadway system

6.1 TECHNIQUES/STRATEGIES

6.1.1 FLEET MANAGEMENT

Fleet management focuses on the operation of the vehicles and technologies that can be applied to improve vehicle and fleet planning, scheduling, and operations. Fleet management can improve the efficiency and safety of the vehicles, which results in a reliable system that could attract new ridership and help the operation become more cost-effective.

6.1.2 COMMUNICATION SYSTEMS

As with any other component of an ITS, communication is a vital component of an APTS. Various communication techniques and technologies are required to meet the communication needs of such integrated functions as the following.

- Bus and control center communications.
  - Voice
  - Data
  - Emergency
- Fare payment.
- Park and ride operations.
- HOV / express bus lane access.
- Adaptive signal system.
- Intermodal communications.
- Traveler information system.

Bus and control center communications are the critical link to a successful APTS implementation, and often require bandwidths to transmit significant amounts of information over a large metropolitan area. In most instances, these requirements can only be met through the use of a dedicated FCC, licensed service. Other innovative methods, such as transmission overlay of APTS information by commercial FM radio station transmission or use of Radio Data Systems (RDS), have demonstrated capabilities for use as APTS communication technologies.

6.1.3 GEOGRAPHIC INFORMATION SYSTEMS

Geographic Information Systems (GIS) are computer-based systems that combine hardware, software, and procedures to capture, manage, manipulate, analyze, and display spatially referenced data. GIS has been extensively used in transportation-management systems. It is a tool that may be used for planning, operation, management, and maintenance of a public transportation system. Transportation is an ideal GIS application due to the fact that a transportation system and its associated components are spatial in nature.

Applications of GIS in transit management include:

- Service and facility planning for bus routes, bus assignments, scheduling, ridership, parking lots, facilities, shelter locations, running times, accident analysis, and customer complaints.

Operations using street and route maps, service performance monitoring, emergency call location identification, and vandalism location and history.

Market development using maps and data that identify land uses, employment sites, demographics, and travel patterns.

Customer information and service through bus route maps, trip planning and route selections, on-time performance data, and customer data.

Transportation service analyses such as service performance statistics, origin and destination of ridesharing applicants, adherence to the Americans with Disabilities Act, and HOV violations.

amount of data using a relational database and an electronic map. GIS-based systems have shown to be user friendly in terms of interface and operation.

with an electronic map and a relational database. GIS software can run on PCs to mini-computers and workstations. Hardware selection is dependent on the software vendor, size of the geographic

6.1.4 AUTOMATIC VEHICLE LOCATION SYSTEMS

Automatic Vehicle Location systems (AVL) are computer-based vehicle tracking systems. These systems have been used extensively in military and civilian applications such as commercial vehicle fleets, police and fire services, and transit operations. AVLs have many inherent benefits, and depending on the type of technology, can provide the basis for implementation of other APTS components. AVL use in transit operations has significantly increased with the introduction of ISTEA and the Clean Air Act, policies that reorganized the funding structure and parameters for many urban areas.

AVL is expected to have many benefits, including:

- Increased operating efficiency.
- Increased service reliability.
- Improved response to service disruptions.
- Improved detection of mechanical problems.
- Improved driver and passenger safety and security.
- Input to passenger information systems.
- Input to preferential traffic-signal actuators.
- Improved database.

Although AVL are primarily used to identify the location of the vehicle, they are often used in conjunction with other applications. The amount of information that may be transmitted between the bus and the management center is a function of the selected hardware and software systems and the data transmission techniques.

Other APTS applications that are often implemented in conjunction with AVL are:

- Schedule adherence monitoring.
- In-vehicle silent alarms.
- Automatic traveler information system.
- Vehicle component monitoring (i.e., engine components, brakes, etc.).
- Automatic passenger counters.
- Computer-aided dispatch.
- Preferential traffic-signal systems.
- Automatic fare-payment systems.

6.1.5 TRANSPORTATION-MANAGEMENT CENTERS AND TRANSIT-OPERATION SCHEDULE

Transit-management software is designed to optimize the use of all implemented technologies. Transit-management software has been used for computer-aided dispatching, computer-aided service restoration, and service monitoring. Service monitoring is performed through collection of operational data such as vehicle positions, passenger data, traffic and weather conditions, vehicle and driver performances, alarms and calls. This information is then analyzed using various routines in the software to determine such information as schedule adherence, route adherence, status of vehicle components, estimated time of arrivals, service requests, statistical information, and emergencies. In case of an emergency or a service call, the system can determine the best course of action and recommend alternatives for restoring service. Once the plan of action is approved, the system can assist in quickly dispatching appropriate services to the location and rerouting or rescheduling the system to handle the emergency. Using the traveler information system, the system can inform the transit users of the system status and provide alternatives. Transit-management software is part of an integrated management system often located in Transportation/Transit Management Centers (TMC).

A transportation management center can be described as a facility that manages, operates, and maintains a multimodal transportation system. TMCs use a wide range of technologies to manage and control a transportation network that facilitates the movement of goods and people using various modes of transportation. There are two basic tasks performed by a TMC. One is to plan, manage, and operate the transportation system, and the other is to provide information to the users. TMCs may use various technologies to gather and disseminate information. For example, an AVL-equipped bus may provide information about its location. The TMC can use this information to estimate the time of arrival at the next stop and automatically display this information on the wayside and/or on-board electronic signs.

More detailed information regarding TMCs is their operation is available in Chapter 7.

6.1.6 TRAVELER INFORMATION SYSTEMS

Traveler information systems provide the transportation-system user with information regarding one or more modes of transportation. This information can be provided pre-trip or en-route. The user may access the information at home, work, a transportation center, wayside stops, on board the vehicle, or through various technologies while traveling. Information that may be provided to the users is grouped into three categories:

General Information. The user is provided with information on available transportation services in the region. Information that may be identified includes transit services, bus or rail, taxi services, major roadways, attractions, and other such information on operating agencies, telephones numbers, and automated linking to agencies' home pages.

Schedule Information. The user is provided with a time table/itinerary for a given trip. Information may include details about the route, fare, schedules, transfer requirements, bus stop locations, and maps.

Operational Information. The user is provided with real-time status of the transportation system or services. In the case of a transit agency, the patrons may obtain information regarding expected arrival/departure times, delays, passenger loading, and congestion so that the user may an informed decision with regard to their trip and available alternatives.

Pre-trip information may be used to plan the mode of travel and/or best route. The pre-trip information may be accessed through the use of:

- Cable television.
- Radio broadcasts.
- Personal computers.
- Personal communication devices.
- Telephone.
- Information kiosks.
- Non-interactive displays.

Many jurisdictions have access to cable television through Government Access Channels. Such channels can be used to display real-time information regarding the transportation network. Radio broadcasters are often interested in getting first-hand information from transportation managers to keep the listeners informed. Personal computers and the Internet have opened a whole new world for exchanging information. Internet and personal computers allow for a large-scale access to user-specific information. Other information technologies that lend themselves to automation are telephone systems, information kiosks, and personal communication devices.

En-route information can be communicated to the user through:

- Personal communication devices.
- Radio broadcast.
- Electronic signs (wayside and on-board).
- Dynamic message signs.
- Highway advisory radio.
- Kiosks.

The most commonly used en-route information systems for transit applications are wayside and on-board electronic signs. Using some of the technologies already discussed, such as AVL and on-board vehicle logic units (VLU), electronic signs can display real-time route-specific information, such as estimated arrival/departure times and cause/duration of delay. Kiosks can be used at transportation centers or major employment or retail centers to provide specific or network-wide information regarding transit services and the transportation network to assist the user in making an informed decision about their trip.

6.2 TECHNOLOGIES

6.2.1 FLEET MANAGEMENT

Technologies used in fleet management include communication systems, automatic vehicle location, automatic passenger counters (not discussed in this handbook), and transit operations software.

Communication Systems

Alternative communication techniques being used or developed to meet future needs of the APTS include:

- Low-earth-orbit satellite services, which rely on satellite communication services to transmit information.
- Analog/digital cellular. Cellular services provide excellent coverage in most metropolitan areas. Although conventional analog systems are nearing capacity, digital systems may provide some additional capacity.

- FM sub-carrier radio data systems. These systems allow for the overlay of traffic and other information in the frequency sidebands (unused portion of the frequency) of commercial FM radio stations.
- Personal communication services. This technology is still in development.
- Spread spectrum systems. These systems use a low power signal to transmit over a band of frequencies. The system selects which band to use based on availability. Because of this, low-power signal spread spectrum systems do not require FCC licensing. However, these types of systems have limited range and may require numerous antennas and repeater stations.
- Shared spectrum technology is sharing a spectrum with other public agencies using digital features of trunking. Examples of these systems are 800- and 900-MHz systems.
- Wireless data services. This is the utilization of wireless data services such as Cellular Digital Packet Data (CDPD) and commercial services such as ARDIS.
- Commercial mobile radio, which has limited use.
- Integrated communication systems. These systems may include a combination of mobile radio and other technologies listed above.

Although each of these technologies may be used in APTS applications, selection depends on the performance requirements, cost of operations, and the availability of spectrum.

Automatic Vehicle Location

An AVL system may be thought of as two components: the location technology and the data transmission methodology. Location technology include hardware and software that are required to determine the vehicle location. Data transmission methodology determine the process by which the vehicle and the management center exchange data.

Location Technologies

An AVL system may employ one or more of the following technologies discussed in this section. Often AVL systems, especially in large urbanized areas, require the use of more than one location technology to meet the requirements of the system.

a. *Signpost and Odometer*

Sign and odometer technology required the installation of signpost (electronic transceivers) along bus routes, installation of an on-board computer and transceiver in each vehicle, and means to transmit information from the signpost to the traffic management center. The signpost, normally mounted on utility poles, communicates with the vehicle using a low-powered signal. The information may be exchanged as the vehicle passes a signpost. One method is that the signpost transmits its unique identification information to the vehicle. The onboard computer uses the information about the signpost location and the vehicle information to calculate the vehicle's location and transmit this to the managment center. By another method, the vehicle has a transmitter with a unique ID that it transmits to the signpost as the vehicle passes by. The signpost then transmits the information back to the managment center for processing. The first method allows for locating the vehicle at any time, while the second method can only identify the status of the vehicle at the last signpost. It should be noted that the second method does reduce the radio traffic and the need for reserved frequencies.

Although signpost and odometer technologies have been well-tested and proven, there have some drawbacks. Some limitations of this type of AVL system are that the routes are fixed and modifications to the route require additional equipment; the amount and type of field equipment could introduce significant maintenance issues; and coverage is available along the route only, thus, the system is incapable of tracking vehicles that stray off-route.

b. *Global Positioning System*

Global Positioning system technology uses signals transmitted from satellites in orbit. The information is received through the on-board receiver and computer, and can be transmitted to the management center. GPS works anywhere a satellite signal can reach. However, the signal cannot penetrate tunnels, buildings, and/or foliage. For this reason, many systems that utilize GPS technology utilize a secondary system to complete the coverage where urban structures and heavy foliage could interfere with the satellite signals. Any of the other location technologies may be used to complement the GPS system. The recent implementation of AVL in the Atlanta MARTA system used dead-reckoning technology to supplement the GPS system.

Although there are systems under design using signpost technologies, most of the new AVL systems are being designed using the GPS technologies. This can be attributed to the GPS flexibility, lower maintenance requirements, broader coverage area, and added security due to consistency of surveillance.

c. *Radio Navigation/Location*

Ground-based radio includes Long Range Aid to Navigation (Loran-C). Loran-C uses low-frequency waves to provide signal coverage. It determines location based on the reception of transmissions and the associated timings from various transceivers. Its performance is significantly reduced in urban areas, and is highly susceptible to radio frequency and electromagnetic interference from power lines and substations in urban and industrial areas.

However, there are private providers of radio-locating services that operate very effectively in an urban area due to blanketed coverage using an 800- or 900-MHz band. Often, these are cellular providers that have already made a significant investment in building an infrastructure to support this type of activity with minor modifications. Multiple users and users of the radio towers tend to keep the subscriber's rates affordable.

d. *Dead-Reckoning*

Dead-reckoning utilizes the odometer reading of the vehicle, and may include an on-board gyroscope or compass and a computer to determine the vehicle's location in reference to an established station. Dead-reckoning technology is often used to supplement one of the other location technologies and is not used as the primary system. If the GPS or radio signal is lost due to obstructions (e.g., tall buildings, tunnels, bridges, foliage), the vehicle can still be located with some degree of accuracy, using dead-reckoning technologies, until the signal transmission can be reestablished.

6.3 CASE STUDIES

6.3.1 CALIFORNIA ADVANCED PUBLIC TRANSPORTATION SYSTEMS

In partnership with both the Federal Transit Administration and the Federal Highway Administration, the California Department of Transportation (Caltrans) has established the California Advanced Public Transportation Systems (CAPTS) program. This program and its resultant public/private partnerships may soon enable attainment of a cost-effective personalized public transportation system that is competitive with the private automobile.

The CAPTS projects are among the various field operation tests underway throughout California.

The Los Angeles Smart Traveler (Test Over)

Smart Traveler operational test partners include Caltrans, California's Health and Welfare Agency, the Los Angeles (L.A.) Metropolitan Transportation Authority (MTA), and private sector affiliates Pacific Bell Telephone, International Business Machines (IBM), and Commuter Transportation Services (CTS), Inc.

Smart Traveler brings together a number of existing systems from different agencies. Caltrans maintains a freeway conditions map that provides traffic speed information from more than 1,000 points on the freeway system, and presents it in the form of a color-coded map updated approximately every 30 seconds. MTA has a transit database which provides route, schedule, and fare information for all bus and transit lines serving L.A. County. CTS maintains the region's ridesharing database, that contains origin/destination information on individuals interested in carpooling or vanpooling.

These three agencies are linked electronically to provide the user with information from each of them via any Smart Traveler communications interface. Pretrip and en-route Information is available to travelers who wish to plan or reroute their trip, reschedule it, or choose another mode of travel based on projected delays. Ride matching and reservation services are available through a toll-free telephone number with a bilingual audiotext, touchtone responsive information system. Callers are able to register with CTS over the phone; once registered, they are able to hear a list of trip-matching registrants read back to them over the phone. They are also able to record a voice message to be automatically sent over the phone to all those who appear on their matchlist.

Los Angeles Smart Traveler Kiosks (Test Over)

Seventy-eight bilingual, automated, multimedia kiosks were installed within the greater Los Angeles area of California as part of the Los Angeles Smart Traveler field operational test being carried out by the California Department of Transportation's Advanced Public Transportation Systems Group. As a consequence of the Northridge earthquake, the Smart Traveler Kiosk element was expanded from a limited test to an extensive network of kiosks providing area travelers with information on transportation options. One of the principal objectives of the field operational test is to assess the effectiveness of this method of disseminating traveler information to influence travel behavior.

The kiosks utilize a personal computer-based system, connected via dedicated digital telephone lines to a telecommunications system established by California's Health and Welfare Agency Data Center in Sacramento. This system accesses the rideshare, transit, and freeway-conditions information residing in databases maintained by Commuter Transportation services, Inc., Los Angeles County Metropolitan Transportation Authority, and CalTrans Transportation Management Center in Los Angeles. The kiosks provide personalized transit itineraries including routes, fares, schedules, and origin-to-destination travel times; carpooling possibilities; real-time freeway conditions; and videos on various transportation topics such as "driving tips" and "effect on the environment." The user interface is a touchscreen monitor. Freeway flow status is displayed on a map. The videos are stored on a laser disc within the kiosk. All other information is displayed in textual form. Carpool match lists and transit information can be printed by the kiosk.

Caltrans' Automated Transit Pass - The Los Angeles Smart Card (Test Over)

Partners in this field operational test include Caltrans, the L.A. Metropolitan Transportation Authority, the L.A. Department of Transportation, the City Transit Departments of Torrance and Gardena, and Echelon Industries, Inc.

Electronic Payment Services allows travelers to pay transit bus and rail fares, parking fees, and road tolls without using cash. The smart card is more convenient, reduces the delays caused by travelers queuing up to pay, and increases security by reducing cash on hand. Eventually, card functions may increase to cover purchases such as gasoline and snacks, much as a bank Automated Teller Machine (ATM) card can be used now. System components include passenger transaction cards, an automated card reader/writer on board the bus, a downloading device for daily or weekly information retrieval, the central processing system, centralized funds transfer and processing functions, and a mobility management center for dissemination, renewal, and security of cards.

Santa Clara County Smart Paratransit Demonstration

Smart Paratransit Demonstration partners include Caltrans, Santa Clara County Transit District, Outreach Paratransit Broker, Trimble Navigation, UMA Engineering, and Navigation Technologies. When travelers with disabilities request transportation from the regional paratransit dispatch center, the system makes a reservation and routes a vehicle to them. For cost-effectiveness, the traveler is transferred to a fixed-route mode as soon as is practical.

Personalized public transit service thus provides disabled travelers with transit access to previously unreachable locations, and acts as a specialized feeder service to regular mass transportation lines. Personalized public transit service is especially valuable in rural areas, where fixed-route service is too costly to maintain.

The service is enabled by automatic vehicle location technology, demand responsive dispatching software, and a navigable map database. These advanced technologies allow the dispatcher to locate the closest vehicle to the requester and to route it via an in-vehicle display to guide the driver.

Ventura/Lompoc Smart Card (PASSPORT)

The Ventura/Lompoc Smart Card Demonstration project is an expansion of the Los Angeles Smart Card Field Operational Test. Its purpose is to complete the development of the comprehensive, integrated Passenger Transaction Unit and Vehicle Monitoring System. This project researches an advanced transit fare payment media (Passport), automated passenger counters, improved radio communications for demand-responsive operations, speech systems and displays for bus stop announcements, and high speed printers for transfers.

Ventura County's Smart Cart (Passport) is a high-tech, prepaid bus pass that lets the user get around all of Ventoura County. The Passport may be paid for and "recharged" by telephone or mail. As of January 1996, the Smart Passport was valid on every public transit system in the County. In Ventura, seven transit operators have been supplied with systems to track vehicle location, produce synthesized speed messages, utilize local area radio for up and down-loading data in their garages, as well as fare transaction units for both passengers and drivers on a total of 75 vehicles. In Lompoc, 10 vehicles have been supplied with fare transaction units and radios. An area-wide radio-based station to accommodate centralized dispatching operations has been developed with an interactive, graphic-based system integrated with fare transaction system.

The Ventura/Lompoc Smart Card demonstration project is funded by the FHWA, the FTA and Caltrans.

Transit Probe

The transit probe project is a multi-jurisdictional transit effort whose vision is to integrate transit and traffic management with Advanced Traveler Information Systems (ATIS) to benefit transit agency operations and partner with traffic management agencies. It will provide the public transit rider with real-time transit information from which better informed travel plans can be made.

Transit Probe calls for fixed-route transit vehicles to be equipped with GPS receivers, and will travel along bus routes within Orange County as probes and will provide highly accurate location, speed, and time data to a central dispatch station. Value-added information such as arterial freeway congestion, incident data and transit information will be derived from GPS data and disseminated. Transit information will be dispersed to the general public via strategically located kiosks throughout Orange County. Traffic related information will be transmitted via TravlTIP to partner agencies (Caltrans District 12, the City of Anaheim, and the City of Santa Ana) to enhance arterial and freeway traffic operations and management.

Transit Probe, a $3 million demonstration project, is sponsored by the FHWA and Caltrans.

6.3.2 DENVER SMART VEHICLE SYSTEM

The Regional Transportation District (RTD) in Denver has implemented an Automatic Vehicle Location Management and Monitoring System (AVL/MMS) operational test. This project is sponsored by the Federal Transit Administration under its Advanced Public Transportation Systems (APTS) Program. Westinghouse Electric Corporation was awarded the contract for implementation of the AVL/MMS. Their proposal incorporated a global positioning system GPS for vehicle location.

RTD's major objectives in implementing the AVL/MMS are:

- To improve the ability of dispatchers to adjust on-street operations.
- To provide accurate and real-time information to the riding public.
- To increase safety through better emergency management.
- To develop more efficient schedules.

RTD provides public transit services to six counties in the Denver region, covering an area of about 2,300 square miles. RTD operates more than 800 buses. The heart of the new communications system is the Operations Center, where fleet activity is controlled. The Operations Center is equipped with state-of-the-art dispatch consoles and computer work stations. The CAD feature gives the dispatcher greatly improved awareness of what is happening on the street and the ability to take quick action to rectify service anomalies. The MMS receives location and schedule-adherence information from each vehicle. The vehicle is displayed on a computer monitor as an icon overlaid on a map of the Denver area. Each bus icon is color-coded to indicate the degree of schedule adherence. Vehicle location is updated on the dispatcher's monitor every two minutes under normal conditions. Other route, schedule, and incident data are reported to the dispatchers on an exception basis and displayed on a separate monitor.

Each RTD vehicle is equipped with an integrated radio/AVL package, which consists of a conventional mobile radio, an onboard processor, a driver interface, and a GPS antenna. The vehicle odometer is connected to the onboard processor to provide movement/distance data to the system for the dead-reckoning feature, which supplements the satellite information in areas where satellite signals cannot be reliably received. The onboard processor receives the GPS information, calculates the vehicle's position, and compares that position to the schedule. The vehicle position and schedule-adherence information is transmitted routinely to the Operations Center during the regular reporting sequence. Exceptions or incidents are transmitted immediately. The onboard processor also serves as an interface and distribution center to control the radio, switch signals from voice to data, and send/receive signals to/from various input/output devices such as the driver console, handset, external microphone, and public address system.

The driver console (called the Transit Control Head) allows the driver to communicate with the dispatcher or send various preset messages. In case of an emergency, the driver can activate a silent alarm switch to alert the dispatcher. The dispatcher can then activate a covert microphone located on the bus to monitor the emergency situation. At the same time, the onboard processor will report the bus position at a more frequent interval to allow more accurate tracking of the vehicle in distress.

The system uses nine radio channels, two for data and seven for voice. Transmitters are located at three different sites in the Denver metropolitan area. The CAD system selects the site and the available channel for best reception and channel utilization. Information generated by the system will be used to generate reports for use in evaluating transit system performance and providing data for operational and policy decision making. Real-time information obtained through the AVL/MMS will be used to update the arrival/departure time information displayed on signboards at the two downtown transit terminals. It will also be channeled to RTD's Telephone Information Center (TIC) for use by the operators in providing real-time information to customers. In addition, as part of another ITS operational test, information kiosks providing real-time transit information are installed at the new Denver International Airport and selected bus terminals and park-and-ride lots.

6.3.3 MILWAUKEE SMART VEHICLE

The Milwaukee County Department of Public Works Transportation Division (MCTD), is deploying an Automatic Vehicle Location (AVL) system. On 602 buses, MCTD is installing a Global Positioning System (GPS) based AVL system-a 15 channel trunking radio system (800 MHz) and onboard computer that controls all vehicle subsystems. The AVL system tracks vehicle locations. By integrating the CAD software with the AVL system, MTCD has the capability to dynamically route and schedule vehicles.

Phase 2 testing is underway and is scheduled for completion by Fall 1996. During this testing period, all system functions are being exercised. After phase 2 testing, the system will be tested under normal operating conditions for a period of 30 days. MCTD plans on disseminating real-time transit information through various traveler information systems and may test flexible-routes and bus signal priority (September 1996).

6.3.4 MARYLAND

Montgomery County is installing GPS-based fleet-management equipment on 250 of its buses, to allow monitoring of traffic congestion, bus schedule and route adherence, and increase vehicle security. Transit data will be gathered at the Montgomery County's Transportation Management Center and fused with data being gathered by the traffic management system. This data will form an intermodal database that will be used by traffic and transit managers for operation, and provided to the public via Internet, pager network, telephone, and television. This system integrates both traffic and transit data in one common intermodal database. Dispatchers can view transit vehicle locations as well as traffic-signal information on a single map, providing them with true intermodal information.

In Baltimore, the Light Rail System running up and down Howard Street (downtown Baltimore) is equipped with signal-preemption equipment. The system is based on AVL using GPS, and will enable the light rail vehicle to determine its position autonomously and request a green light as it approaches the next traffic signal. Subsystems are installed on the vehicle, on the wayside, and at intersections.

The traffic-control equipment communicates with the wayside equipment and the Baltimore Traffic Control Center, incorporating schedule-adherence and vehicle-status reporting.

6.3.5 OREGON

In Portland, OR, an AVL system relies on GPS location data and radio-based voice and data communications to collect and deliver data that helps keep buses on schedule, in turn making bus service more reliable for riders. The system also keeps the Tri-Met customer service operators informed of bus locations so that they can notify callers when a bus is running behind schedule and suggest an alternative route. It also collects operations data, such as bus arrival times, that the Tri-Met can use later to improve bus scheduling (ITS World, Jan/Feb 1997).

6.3.6 KANSAS CITY

The Kansa City Area Transportation Authority is using AVL technology to track its fleet of 280 buses. It has installed an automatic vehicle locator on each, and “smart” signposts along the roadways to read and communicate bus locations directly to the computer-aided dispatch center. Dispatchers and drivers work together to stay on schedule.

At dispatch headquarters, a console monitors the real-time, precise position of each bus and compares it with the bus’ planned route and schedule. Dispatchers can focus on those buses that are ahead of or behind schedule and make appropriate adjustments. A digital readout in each bus provides the driver with the same real-time information, indicating whether he or she is running early or late on the scheduled route. The system also equips each bus with a silent alarm for emergency communications.

Under the AVL system, on-time performance of the transit system rose from 78 to 95 percent. Buses on schedule 95 percent of the time are more reliable and, consequently, more attractive to commuters and other customers. With this greater efficiency, Kansas City was able to eliminate seven buses from its routes without adversely affecting service to its passengers—and save more than $400,000 in annual operating expenses. The system provides another benefit: fast response in the event of crime, medical emergency, or other crisis. By pinpointing bus locations, the system slashes a response time of 3 to 10 minutes to approximately 1.

6.3.7 ANN ARBOR SMART INTERMODAL

Ann Arbor Transportation Authority (AATA) is deploying the Smart Bus concept—Automatic Vehicle Location (AVL) and Computer Aided Dispatch (CAD) system, vehicle component monitoring, Automated Passenger Counters (APC), Electronic Fare Payment (EFP) system, and in-vehicle video surveillance system. On 76 buses and 5 paratransit vehicles (subcontractor), AATA is installing a Global Positioning System (GPS) based AVL system-a trunking radio system (800 MHz) and onboard computer that controls and monitors all vehicle subsystems. The AVL system tracks vehicle locations, provides real-time data to traveler information systems, and triggers digital announcements and internal displays in the bus. AATA is disseminating real-time transit information via the Internet, kiosks, and cable television. By integrating the CAD software with the AVL system, AATA has the capability to dynamically route and schedule buses.

The status of critical engine components is also monitored by the onboard computer. Electronic sensors installed within the engine continuously monitor critical vehicle components and report any out of tolerance conditions to the onboard computer which relays the information to the dispatch center via the data channel. Finally, AATA is installing a three camera video surveillance to increase driver and passenger safety (September 1996).

6.3.8 BALTIMORE SMART VEHICLE

Maryland's Mass Transit Administration (MTA) is implementing an Automatic Vehicle Location (AVL) system and Computer Aided Dispatch (CAD) system. A prototype AVL system, LORAN-C receivers and 800 MHz radio, was previously tested on 50 buses and was successful. However, due to emerging AVL technologies, Maryland MTA is installing a new AVL system. On 200 transit vehicles (165 buses and 35 light rail vehicles), Maryland MTA is installing a Global Positioning System (GPS) based AVL system-a trunking radio system (800 MHz) and onboard computer that controls all vehicle subsystems. The AVL system tracks vehicle locations. By integrating the CAD software with the AVL system, Maryland MTA will have the capability to dynamically route and schedule vehicles.

TMS Engineering has finished upgrading the microwave and communication systems. The communication system has been trunked to include a data channel. Currently, the AVL system has been installed on twenty buses. Additional buses are slowly being added, one to two a week, to ensure that the communication systems does not collapse. Maryland MTA has finished surveying the light rail vehicles. Installation of the AVL system on light rail vehicles is scheduled to commence in June 1996. The installation of the entire AVL system is scheduled to be completed by December 1996. The CAD software is undergoing field testing.

In a future project, Maryland MTA plans on disseminating real-time transit information via kiosks and the Internet. Maryland MTA will provide this information to Capital Beltway Showcase's Central Traveler Information System, a $4 million Advanced Traveler Information Systems (ATIS) and Advanced Transportation Management Systems (ATMS) project in the Baltimore/Washington, D.C. corridor. Maryland MTA may expand the AVL/CAD system to the entire transit vehicle fleet. In addition, Maryland MTA may test flexible routes and bus signal priority (September 1996).

6.3.9 CHICAGO SMART INTERMODAL

The Chicago Transit Authority (CTA) is deploying their Bus Emergency Communications System (BECS) and Bus Service Management System (BSMS). The BECS is a comprehensive communications base designed to support more effective delivery of bus service. New two-way voice and data radio system, and location capabilities are the main features of BECS. Under the BSMS, CTA is installing additional hardware and software modules to support Computer Aided Dispatch (CAD) software, transit priority movements at five signalized intersections, electronic traveler information way-side signs at two major bus stops, and enhanced data reporting system. Modules are only being installed on buses assigned to the 77th Street garage.

CTA awarded the contract to OSC in February 1996. The new fixed voice and data radio infrastructure is scheduled to become operational in early 1997. All 264 buses are scheduled to be equipped in early 1998.

CTA plans on deploying the BECS and BSMS to the entire bus fleet, approximately 1,800 buses. After systemwide deployment, some possible future enhancements are Computer Aided Service Restoration (CASR), automatic passenger load estimation, onboard electronic signs and annunicators, Electronic Fare Payment (EFP) system, and Automatic Passenger Counters (APC) (September 1996).

6.3.10 DALLAS PERSONALIZED PUBLIC TRANSIT

Dallas Area Rapid Transit (DART) is testing flexible-route buses on a regional crosstown route in the Dallas metropolitan area to determine if flexible service can increase ridership. By integrating DART's existing Automatic Vehicle Location (AVL) system and an off-the-shelf Computer Aided Dispatch (CAD) software, slack in a bus' schedule can be calculated. If there is sufficient slack, a fixed-route bus may deviate and pick up off-route passengers at a designated location. DART's Geographical Information System (GIS) is used to identify the exact location of the off-route passenger pick-up point. The maximum route deviation is one mile.

In April 1996, FTA awarded the cooperative agreement to DART. DART is currently developing a technical work plan and project schedule. DART may expand flexible-routes to other areas (September 1996).

6.3.11 DALLAS SMART VEHICLE

DART is also implementing an Automatic Vehicle Location (AVL) system. On 823 buses, 200 paratransit vehicles, and 142 supervisory and support vehicles, DART is installing a Global Positioning System (GPS) based AVL system-a 12 channel trunking radio system (900 MHz) and an onboard computer that controls all vehicle subsystems. The AVL system tracks vehicle locations.

Final acceptance of the system occurred in February 1996. Electron Automation is still fine tuning the system. A major concern is maintenance of the route and schedule software because different databases feed the software. During the next three months, new software is being written to resolve the problem. The project is 99 percent complete. DART plans on disseminating real-time transit information through the Internet and kiosks and may test bus signal priority (September 1996).

6.3.12 DELAWARE COUNTY (PENNSYLVANIA) RIDETRACKING

Delaware County Community Transit (DCCT) is deploying a ridetracking system-automated identification cards, Mobile Data Terminals (MDT), automated scheduling and dispatching, and radio frequency data communications. The automated identification cards certify that the card holder has access to service and ensures that the parton's sponsoring agency or agencies are charged appropriately for the trip. The identification card interacts with the MDT to identify the customer to the driver and to verify trip eligibility. Furthermore, the card creates a trip record-trip length and duration-that is used in the billing process to reconcile scheduled trips versus actual trips. Automated scheduling and dispatching and radio frequency data communications improve the ridetracking system's efficiency (September 1996)

6.3.13 NORTHERN VIRGINIA SMART ROUTE SYSTEM

Potomac-Rappahannock Transportation Commission (PRTC) is deploying their Smart Flexroute Real-time Enhancement System (SaFIRES)-Automatic Vehicle Location (AVL) system, Computer Aided Dispatch (CAD) software, Mobile Data Terminals (MDT), and Geographical Information Systems (GIS). SaFIRES assigns the most appropriate vehicle-fixed and flexible-route buses, and health and human services transportation-to respond to a transportation request in a low density environment. On 50 vehicles, PRTC is installing a Global Positioning System (GPS) based AVL system—a three-channel trunking radio system and onboard computer that controls and monitors all vehicle subsystems. The AVL system is used to monitor bus locations and triggers digital announcements in the bus. By integrating the CAD software with the AVL system, PRTC has the capability to dynamically route and schedule buses.

PRTC is also testing flexible-routes to determine if this type of service can increase ridership. If there is sufficient slack, a fixed-route transit vehicle may deviate from its route and pick up off-route passengers. PRTC's GIS is used to identify the exact location of the off-route passenger pick-up point. The maximum route deviation is three-fourths of a mile. Finally, SaFIRES streamlines the National Transit Database reporting process and tracking of health and human services transportation ridership. The AVL system and MDT have been installed on 22 vehicles. The CAD software is being tested and debugged. Testing of the communications system was scheduled for July 1996 (September 1996).

6.3.14 WINSTON-SALEM MOBILITY MANAGER

Winston-Salem Transit Authority (WSTA) is testing the Mobility Manager concept by implementing the Paratransit Automated Scheduling System (PASS). PASS is a software package that automates the dispatching of paratransit service and is a comprehensive management information system that automates the reporting and billing of paratransit service. On three paratransit vehicles, WSTA is installing an Electronic Fare Payment (EFP) system and a Global Positioning System (GPS) based Automatic Vehicle Location (AVL) system-a trunking radio system and onboard computer that controls and monitors all vehicle subsystems. The AVL system tracks bus locations.

With the project in Phase Two, fixed-route buses, vanpools, carpools, and taxis are being incorporated into the Mobility Manager. WSTA plans on disseminating real-time transit information through various traveler information systems and may test bus signal priority. WSTA may expand the AVL system to the entire fixed-route and paratransit fleet (September 1996).

6.4 EVOLVING TECHNOLOGIES

Automatic Vehicle Location (AVL)

Global Positioning System (GPS)-based AVL systems are used for transit fleet management to monitor transit vehicles along routes, permitting quick response to changing needs, breakdowns, and vehicle or passenger emergencies.

Real-Time Computer-Aided Dispatch

Real-time computer-aided dispatch is an integrated transit scheduling and recutting system that provides real-time information to dispatchers.

On-board Sensor

On-board sensor systems automatically monitor passenger loadings, location of the vehicle, fare box revenue, operating condition of the engine, and other equipment.

Smart Traveler Technologies

These systems (e.g., kiosks, interactive displays on computers, cable TV) provide real-time information to travelers at home, the workplace, or transit centers that help travelers choose their mode of travel or alter their route due to delays.

Smart Intermodal Systems

Smart intermodal systems involve integrated electronic payment for transit, highway tolls, and parking all through one payment medium for a range of intermodal services. This involves imaging technologies as well as smart cards, tracking, and AVL systems.

Dynamic Ride Sharing

Dynamic ride sharing is intended to match travelers to drivers forming carpools dynamically.

Etak, Inc. has developed SkyMap, a complete map and satellite navigational system that works with a personal computer. Priced around $400, SkyMap features a digital map database, comprehensive traveler information, a global positioning system antenna that includes a PCMCIA card connection, and a remote control. The new system converts a laptop PC into a complete mobile navigation guide, tracking a traveler's progress in real-time on detailed "moving maps" that display cities, major streets, and highways throughout the continental United States. (www.itsonline.com/attn/msg00010.html)

TranSmart Technologies, Inc. recently released TrafficOnline (TOL) V1.0. The company calls this "the first tool for receiving customized real-time traffic information for major U.S. cities." TOL is an interactive Internet shareware program that uses patent-pending technologies to provide, via personal computer, customized, route-specific and point-to-point real-time information on travel time, speed, incidents, construction and weather; clickable real-time congestion maps of major city highways;

automatic warning of abnormal route travel times via TOL or automatic e-mail; and automatic updates of real-time traffic information (www.itsonline.com/attn/msg00009.html).

Etak has partnered with Metro Networks to provide "the first nationwide real-time traveler information system." Traffic information will be delivered via multiple technologies, including wireless products (e.g., palmtop computers, pagers, cellular phones) and fixed devices (e.g., home computers, interactive TV, interactive kiosks) (www.itsonline.com/itsnews.html).

Radio Broadcast Data System

Radio Broadcast Data System (RBDS) is able to receive traffic announcements that are broadcast even when the traveler is listening to another station or to a cassette or CD. The broadcaster can send a signal to the RBDS radio to "break-in" to whatever the traveler is listening to and announce the traffic information. At the end of the announcement the radio will switch back to whatever the traveler was listening to before.

Conventionally, radios display the frequency of the station you are listening to. On RBDS radios, the name of the station (rather than the frequency) is displayed. In the future one will see a display of short messages, such as song titles, artist information, and inevitably advertising messages (www.dungeon.com/~start/rdsst.html).

RBDS technology is a way of sending information directly to wireless receivers. One of the initial uses for this technology is to broadcast accurate real-time traffic information directly to vehicles or smart information kiosks. Another use for RBDS is to broadcast differential correction information for use by global positioning system receivers.

Currently traffic information is widely available through commercial broadcast radio; however, it does not always reach the traveler at a time or location where the information is useful. By using RBDS technology, timely traffic information is delivered directly to an instrumented vehicle or kiosk. Thus, relevant traffic information is always available to the traveler.

The Phoenix Deployment Test

Real-time traffic information is gathered from the Arizona Department of Transportation, city of Tempe, Metro Networks and Skyview Traffic Watch Inc. Crusader Software (PC NT 3.51) developed by Daltek AB is used to encode the traffic information. Differential Corrections, Inc. broadcasts the encoded information from KSLX FM 100.7 radio station. Volvo systems (Dynaguide in-vehicle and PC-based units) overlay the traffic information onto Maricopa County Department of Transportation maps of the metropolitan Phoenix area. Retki software developed by Liikkuva (running on notebook PCs) overlays the traffic information onto Etak maps of the metropolitan Phoenix area (www.azfms.com/About/rbds.html).

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Return to Table of Contents