CHAPTER SEVEN

CASE STUDIES

Several of the U.S. transit agencies that responded to the synthesis survey were interviewed by telephone to obtain more detailed information on their real-time bus arrival information systems. In addition, a visit was paid to London Bus Services Limited, a division of Transport for London, to obtain detailed information about one of the most visible and successful real-time bus arrival systems in the world. Also, information was obtained about two other systems. The results of the interviews, the site visit to London Buses, and additional information on agency systems are presented here.

REGIONAL TRANSPORTATION DISTRICT, DENVER

RTD was one of the first public transportation agencies to deploy a GPS-based AVL system. The decision to purchase the AVL system was made in 1992, with final system acceptance in 1996. In 1999, RTD began looking at using the AVL data to provide real-time information to customers. In December 2001, RTD introduced Talk-n-Ride, a telephone service that provides real-time bus (and light-rail) arrival information. RTD already provided and continues to provide real-time bus arrival information (called Bus Locator) through its website at http://www.RTD-Denver.com (see Figure 18) before the introduction of Talk-n-Ride.

Customers using Talk-n-Ride can provide the key information, route number, direction and stop name to the system by voice to obtain the ETA for the next three buses at a particular stop. The ETA calculations are done based on data from RTD's AVL system. RTD does not report an ETA for anything less than 5 min, and it only reports a delay only when a bus is 5 min or more late.

RTD provides PDA and web-enabled mobile telephone access to real-time information using the same customer inputs as Talk-n-Ride. The same server and software are used to provide ETAs by means of a PDA and mobile telephone as used for Talk-n-Ride and Internet applications. An interpreter program determines the type of device that is requesting ETA information and the operating system being used by that device. Once the system determines the device type and related operating system, the ETA prediction

FIGURE 18 RTD schedule page with bus locator option.

is calculated and provided to the requesting device in the correct code (determined by the operating system of the device). For example, data are returned in WML 2.0 if the mobile telephone requesting the ETA information is running WML 2.0. A total of 440 devices and multiple versions of XML, WML, and HTML are supported.

RTD built the software applications to provide ETA information in-house, but it partnered with several vendors to provide the mobile and voice applications. Two full-time staff members were added to the information technology department to handle the provision of real-time information. One person writes applications to maintain the Oracle database used by the applications. Another full-time person is needed to manage the work being done by consultants, to maintain the system, and to address other system-related issues.

One issue that is currently being addressed by RTD staff is when a bus interlines. Currently, ETA information is not accurate for this situation. For example, if a bus interlines from an airport route and a northeast suburb, the last timepoint may be at the airport. Then, the bus has a layover and it interlines to a new route. Currently, ETA information for the first stop on the new route is not correct. “Dummy” timepoints are required for the first stop to have accurate ETA information. Pullouts cause a problem similar to interlining. RTD is currently addressing both of these issues.

RTD also has 60 kiosks located in and around the Denver metropolitan area (see Figure 19). Because these kiosks provide RTD’s Internet site, real-time information can be obtained from them.

RTD will be testing a vendor-supplied, real-time bus arrival information system. This system, which will consist of 20 electronic signs on three bus routes, is expected to be operational by the end of 2002. The vendor’s system will use RTD’s location data, generated by the existing AVL system, with the vendor’s own algorithm to predict arrival times.

FIGURE 19 RTD kiosk.

KING COUNTY METRO, SEATTLE

King County Metro (KC Metro), the only U.S. survey respondent with a signpost-based AVL system, has been providing real-time information to its customers through the systems BusView and MyBus. These applications were developed by the University of Washington as part of the Seattle MMDI, called Smart Trek. [Information collected by Multisystems, Inc., for this subsection became the basis for part of Chapter 3.1 in Casey et al. (*35*), which deals with the state of the art of such systems.]

BusView provides bus riders with real-time bus location information via the Internet (see Figure 20). In mid-1998, the service became available to the public via the Smart Trek web page. The software application that supports BusView geographically represents the location of 1,300 KC Metro buses traveling on 250 routes throughout its large service area. Development of the BusView application cost approximately $230,000. The raw bus location information is supplied by KC Metro’s AVL system, which was upgraded for the real-time information with approximately $1.2 million of MMDI funding. On-board hardware and system software were upgraded to accommodate real-time information.

The University of Washington’s ITS Research Program, part of the Washington State Transportation Center, developed the software algorithms needed to achieve the necessary time and location accuracy for BusView displays. The center’s staff also created the web interface for BusView, which is based on an advanced Java software application. The importance of the Java application is that the information service can run seamlessly on most computer workstations using one of the industry’s standard web browsers. This means that users of PCs, Macintosh, UNIX, or other standard computer platforms can all use the service.

BusView allows transit riders to see exactly where any bus on any route is currently located on a scaled map.

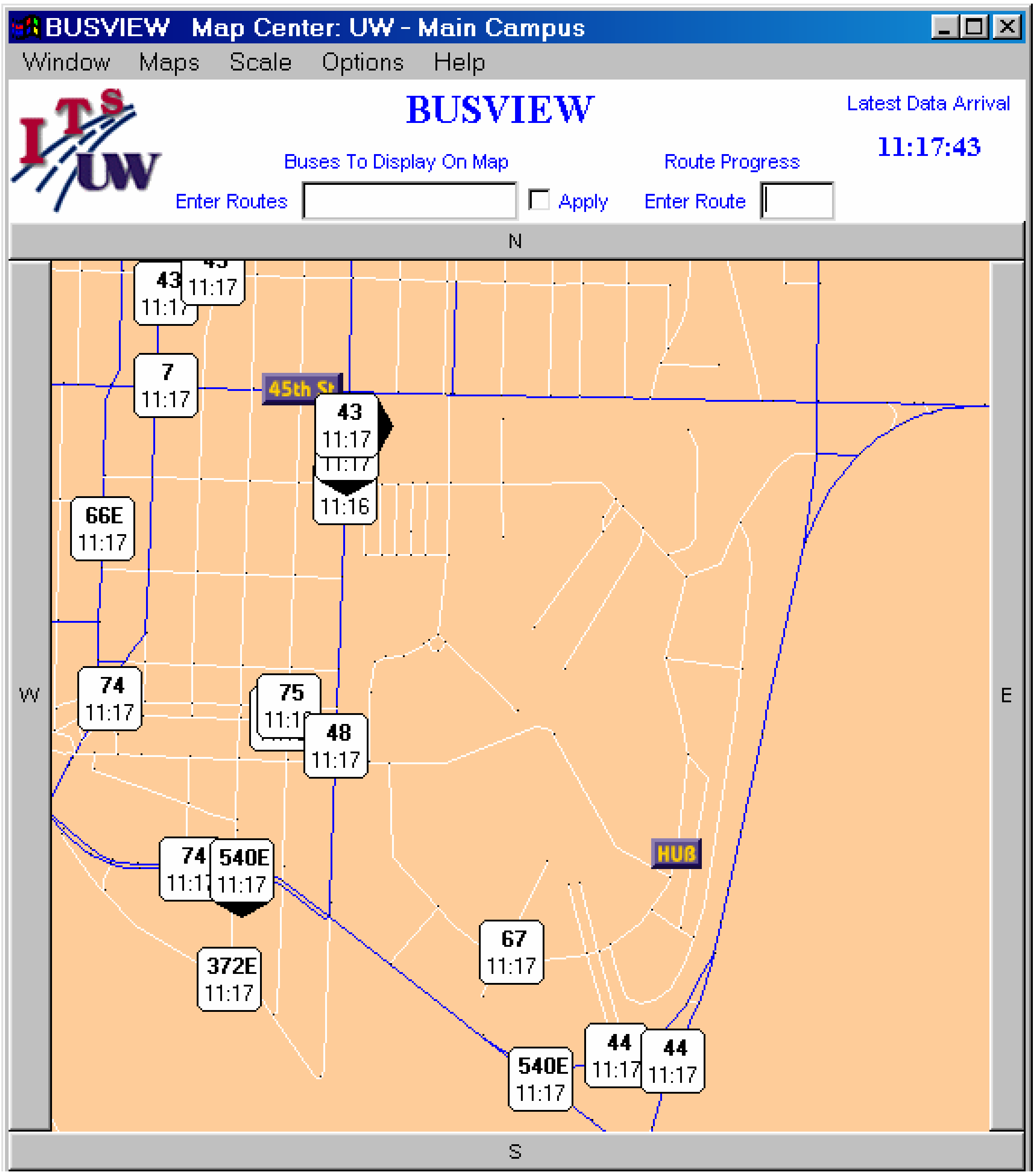

FIGURE 20 BusView main window.

Transit riders can quickly select geographical subareas of interest using a typical drop-down menu to focus on, for example, a region surrounding their homes or workplaces. If the default area is not appropriate for a user's needs, they can easily scroll the map in any direction to display the exact area they want to view.

BusView offers a substantial array of features and customization options. Key features are described here.

On the initial BusView screen, the bus icons show the route number of a bus, direction of travel, and approximate location at its last location report time. Maps are not labeled with streets names, to prevent visual clutter. However, to orient themselves according to a map, users can simply hold the cursor over any designated intersection to display a label of the cross streets. A user can enter specific route numbers into a special "Visual Route Filtering" input box to filter out all other routes in which they are not interested. A "Route Selection" input box enables the user to launch another pop-up box that presents detailed text information about a single route. A user may view two different areas simultaneously by launching a new BusView window and navigating to the second area.

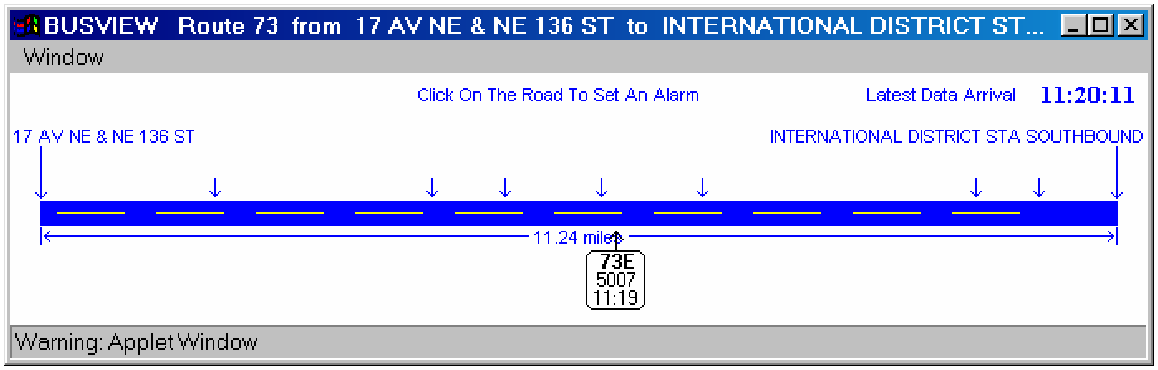

FIGURE 21 BusView progress window.

Clicking on an icon in the main screen allows the user to push it behind or bring it on top of overlapping icons, a feature that is important where the number of routes and combined headways can result in numerous bus icons being placed on top of one another. Clicking on an icon also allows the user to jump to the published timetable or launch a new bus progress screen.

The bus progress window shows a linear representation of an entire bus route (Figure 21). It shows buses for a single direction of travel, based on which direction the bus was moving when the user selected it in the main window. Arrow icons along the route indicate the locations of timepoints in the published bus schedule. By holding the cursor over an arrow icon, the user can view either the timepoint's intersection or the name of a major landmark if the timepoint is a location such as a shopping mall.

By clicking anywhere on the route in the bus progress window, a user can add an alarm clock icon that will produce a visual and audio notification that indicates when the next bus passes that particular point. Using this feature, a rider can, for example, be notified when the next bus is several blocks away from home or work, allowing the user to time his or her arrival at the bus stop.

The BusView applet was designed to allow individual users to customize it for their travel preferences. The first time the service is used, a selection of preloaded maps appears in the menu list of the main screen. If a user's Web browser supports and accepts cookies, then each time a new map is selected, it is added to a list of maps stored in the cookie file. During subsequent use of this service, the map drop-down menu described earlier is updated to include maps chosen previously by an individual user.

In the upper right corner, each BusView window displays the time when data were last received by the system. New data are put into the BusView system approximately every second. Although each data update does not include new location information for every bus, new data are available for each bus approximately every minute. A user can determine roughly how current the time information is on his or her bus by comparing the bus icon time with the window time. The greater the disparity between the two, the less reliable the current bus icon position.

The MyBus system is a pretrip service available via the Internet (see Figure 13), PDA, and mobile telephone. The cost for developing MyBus was included in the $500,000 budget for another Smart Trek project called TransitWatch, as mentioned previously in chapter five. MyBus now provides information previously provided by Transit Watch via the Internet. MyBus provides real-time information for each bus stop and route in the KC Metro system.

TRI-COUNTY METROPOLITAN TRANSPORTATION DISTRICT OF OREGON, PORTLAND

Tri-Met has a three-pronged approach to providing real-time bus arrival information. First, it is beginning to provide real-time bus arrival information on LED signs at bus stops. As of September 2002, 11 signs have been deployed at 10 bus stops (and 28 signs at 11 light-rail stops). The plan is for 50 LED signs to be deployed at an additional 50 sites by the end of fiscal year 2003 (June 30, 2003), dependent upon the availability of power at those sites. Ultimately, Tri-Met would like to outfit a total of 250 sites with LED signs displaying real-time bus arrival information. The arrival sign system was developed by the AVL vendor.

The second part of the approach is to provide real-time information via the Internet to those customers who have Internet access at work or at home. Since September 2002, Tri-Met has provided real-time bus arrival information for every route and most bus stops in the system on the Internet (see Figure 11). Given that Portland has one of the highest Internet penetration rates in the United States, this approach has been highly successful in the short time it has been operational. This Internet service was developed in-house.

The third part of the approach is to provide real-time information on portable (wireless) devices, such PDAs and mobile telephones. This application, being developed in-house, was expected to be available to customers by the beginning of 2003.

The number of signs deployed at bus stops, as part of the first step in the approach, will depend on the success of the Internet and wireless applications. For example, signs will not be deployed in areas of low ridership, which might be better served by the Internet and wireless applications.

Tri-Met does not use a prediction algorithm per se to calculate the real-time arrival information that is displayed on the LED signs. Information that is sent to each bus driver via an MDT about their arrival time at the next stop is sent to the signs. Each sign has the schedule loaded in it, and the sign processor applies the information about arrival time to the schedule, to determine the offset from the schedule. This is a distributed, decentralized system, because information that will be used to determine arrival times is sent to the sign for processing.

In contrast to the way that processing is done at each sign, the Internet and wireless applications determine real-time bus arrival times centrally. The prediction algorithm is centralized. The same logic as used at each sign is used for the centralized prediction process.

Tri-Met believes that providing real-time bus arrival information is a way of improving the customer's perception of the bus service. Although Tri-Met has only recently begun to measure customer satisfaction with the real-time information, it appears that customers perceive that their waiting times are shorter and that the service is more frequent. At one of the key LED sign locations, an intercept survey of 200 people was recently conducted, as described in chapter five. In that survey, customer response was very positive, with the value placed on having Transit Tracker at the bus stop very high—4.5 on a 5-point scale, with 5 having the highest value and 1 having the lowest value.

SAN LUIS OBISPO TRANSIT

San Luis Obispo (SLO) Transit in San Luis Obispo, California, has deployed a unique real-time bus arrival information system, which was developed by California Polytechnic State University at San Luis Obispo (Cal Poly). This system, part of the Efficient Development of Advanced Public Transportation Systems (EDAPTS), was developed and designed by Cal Poly using COTS hardware, plus software developed by the researchers. A functioning model of the system was developed in 1994 and 1995, and the system's concept was fully developed in 1997. Cal Poly began the conceptual stage of EDAPTS by performing a detailed needs assessment of transit ITS in this area of California, and it prepared a Concept of Operations (*36*). Full deployment of the system occurred in 2001.

This system is unique because it was developed with the small transit agency in mind. Using COTS hardware and an existing radio system, this system costs less than traditional systems currently available. The primary goal of EDAPTS is to build a system, including real-time bus arrival information, using COTS technology. Other system objectives include providing passenger information; developing an open source, public domain system that is accessible to small- and medium-size transit agencies; deploying the system incrementally; and providing an affordable, but comprehensive system.

The primary components of EDAPTS are a GPS-based AVL system, on-board MDTs, Smart Transit Signs, and use of the existing analog voice radio system. The real-time bus arrival information displayed on the solar-powered Smart Transit Signs, as shown in Figure 22, is determined as follows. When a bus leaves a stop, the bus in effect knows how it is doing against the schedule. This information on schedule adherence is used together with information about where the bus is on the route, the trip and pattern that the bus is on, and the number of the stop that the bus just stopped at. This information is then sent to the Smart Transit Sign, which maintains a timetable and vehicle assignments for the whole SLO transit system. Then, the software resident in the sign uses the real-time data, timetable, and vehicle assignments to calculate when the bus will arrive at the next stop and subsequent stops.

FIGURE 22 Smart Transit Sign, San Luis Obispo (Calif.) Transit.

Another unique feature of EDAPTS is the use of the existing radio system to provide the communications backbone for the system. "Rather than move the information over specialized data links, the EDAPTS team chose to 'piggyback' the digital data on the standard analog voice radio system" (*37*).

Expansion of EDAPTS is continuing, with a graphical interface, interactive kiosks, an Internet application, and automated announcements being planned.

TRANSPORT FOR LONDON—LONDON BUS SERVICES LIMITED

London was one of the first cities in the world to deploy LED signs at bus stops that indicate the arrival times of the next buses at each equipped stop. This system, called Countdown, was piloted in 1992 by London Buses on bus Route 18. The results of surveys conducted during the pilot indicated that Countdown was highly popular with customers. In 1993 and 1994, Countdown was tested along several bus corridors. In 1996, a London-wide rollout of the AVL and Countdown programs was approved. In 2001, the AVL program was 80% complete, and the Countdown program was 25% complete. As of March 2002, 1,473 Countdown signs had been installed and were operational. The current plan is to have a total of 2,400 signs installed by March 2003 and 4,000 signs by 2005. The 4,000 signs would cover 25% of all stops and will benefit 60% of all passenger journeys. Expenditures for the AVL and Countdown programs total $69.75 million (£45 million).

The London Countdown system is based on the agency's beacon (also known as signpost) AVL system. An on-board AVL unit receives the identity of a roadside beacon as the bus passes the beacon. Because each beacon has a unique identifier, the bus can then determine its location, and the location information is forwarded directly from the vehicle to a central system by means of the on-board radio. Currently, there are 5,000 beacons deployed in the London Buses service area. Figure 23 shows how the AVL and Countdown systems function.

The central system sends information to bus stop signs. There is a modem in the sign that receives the arrival information from the central system, and there is a processor in the sign that determines on the sign the order of bus arrivals. The predicted time to arrival is displayed on the sign, along with the bus route number and final destination (see Figure 3). This time is "counted down" until the bus arrives at the stop.

London Buses continues to conduct an extensive amount of market research to determine customer satisfaction with Countdown and the interest in future enhancements, such as providing real-time information away from the bus stop and siting Countdown signs. Recent market research yielded several key findings.

- Results of 1,125 interviews with passengers waiting at 16 bus stops in North West London included the following (*22*):

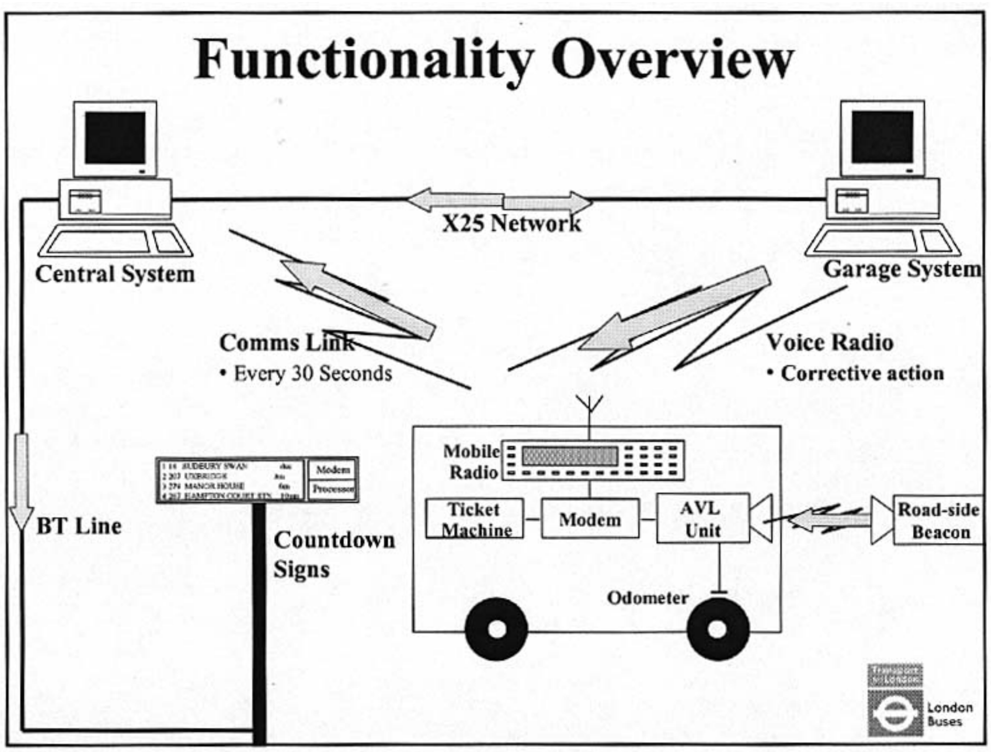

FIGURE 23 London Buses automatic vehicle location and Countdown systems.

- – On a scale of 0 to 10, Countdown achieved an overall usefulness rating of 7.1.
- – High-frequency stops achieved the best overall rating for usefulness at 7.5.
- – Countdown was rated the least useful at low-frequency stops at 6.8.
- – Those respondents who had seen Countdown previously were more inclined to value its usefulness, suggesting a learning process.
- – The main reasons that Countdown was considered useful were that it gives arrival time information and it allows passengers to take alternative action.
- Results of seven group discussions in Shepherds Bush, Islington, and Bromley with regular, infrequent, and very infrequent bus users, included the following (*20*):
  - – Current bus users considered that it was most important to have off-system information available in their homes.
  - – Also important was information on points of interchange with other means of transport and off-system information in supermarkets.
  - – There was more interest in the availability of journey-planning information than in information relating to familiar or regular journeys. More interest was generated in static information than in real-time information.
  - – Current bus users thought telephone and Teletext were the most readily acceptable means of communicating off-system bus information.
  - – Customers would be prepared to pay a small fee for using any new application, but this fee should be kept to a minimum.

Within London Buses, the Monitoring Analysis Route Quality Information System (MARQUIS) was developed to provide "widespread access to route performance information and reports via PCs" (as indicated in a March 2002 handout "About the MARQUIS Project," distributed by London Buses). Ultimately, the primary purpose of MARQUIS is to improve bus service and to understand actual bus operations. Other objectives of the project are

- Allow service providers access to data that will be used to calculate performance,
- Facilitate service provider's evaluation of their own performance,
- Better plan bus services, and
- Reduce paperwork.

MARQUIS, as shown in Figure 24, consists of archived AVL data that is stored on each bus and later downloaded into the system when the bus enters the garage, plus related information about routes and schedules. It has dedicated servers and a report-generation function that can be accessed via the Internet by bus operators and Transport for London staff, and by means of the Intranet for London Buses staff.

The following reports can be generated by using MARQUIS:

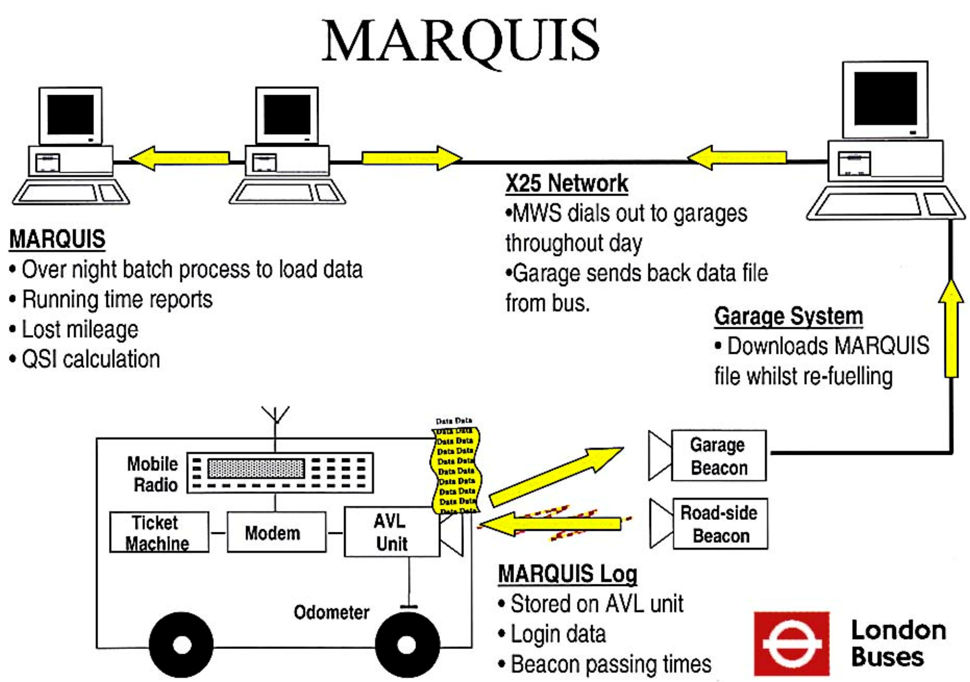

FIGURE 24 London Buses Monitoring Analysis Route Quality Information System (MARQUIS).

- Running time analysis,
- Headway analysis,
- Bunching report,
- Terminal behavior,
- Loaded trip data, and
- Matched trip data.

As of March 2002, 33 garages were outfitted with the MARQUIS software, which included the capability to download the AVL data stored on-board each vehicle.

Overall, London Buses has experienced many of the same challenges that have been prevalent in the U.S. deployment of real-time bus arrival systems. First, there is the challenge of receiving adequate support from outside companies that provide key aspects of the system. These include power, telephone, and shelter companies. Lack of support from these outside firms has resulted in Countdown signs being inoperable and incurring a long lead-time for sign installation—that is 3 months for the shelter, 4 months for the telephone service, 1 month for checking the shelter modifications for the signs, and 1 month for completing the installation.

Second, requiring operators to use the system is a challenge because all service is operated by contractors. As mentioned earlier in the report, operators in London are not under a contractual obligation to use the system. This is an issue for several agencies in the United States as well. As of December 2002, London Buses is in the process of implementing a training program that will ensure that all service controllers and new drivers are adequately trained on the AVL system.

Finally, responding to the needs of the community has also been a challenge. Many London citizens have requested Countdown signs at their neighborhood stops, and there has been political pressure to deploy Countdown in areas where AVL technology has not yet been fully implemented. Similar situations have occurred in several locations in the United States.

ACADIA NATIONAL PARK—ISLAND EXPLORER BUS SYSTEM

The TRACKER system was introduced to support the operations management and passenger information requirements of the Island Explorer (IE) transit system. IE serves Acadia National Park (ANP) and nearby areas in northeastern Maine. The TRACKER initiative was funded through the support of the FHWA, the Maine Department of Transportation (DOT), the U.S. Department of the Interior, and a variety of local interests. TRACKER is only one aspect of a broader Field Operational Test involving several different types of ITS for the ANP area.

IE transit service connects various destinations in ANP with one another, as well as with area hotels, inns, and campgrounds, and with local communities. It has become very effective in providing a viable alternative to automobile use in and around ANP. Downeast Transportation, Inc., currently operates IE from mid-June through Labor Day each year, using 17 propane-powered vehicles. This fare-free service is supported by the National Park Service, the U.S.DOT, Maine DOT, area towns, local businesses, and the Friends of Acadia, a nonprofit organization.

Each bus is equipped with a GPS receiver, which uses information from GPS satellites to continuously determine the vehicle's position. Each GPS receiver is integrated into a mobile data computer (MDC). The MDC also receives a GPS correction via radio to increase the accuracy of the computed vehicle location. Passenger counts and schedule adherence data are sent to dispatch, using the mobile data communication system, when the vehicle passes a "triggerbox" location as it departs each stop. Triggerboxes are locations stored in the MDC that trigger an event when the vehicle has exited or entered a stop. Vehicle location data are sent with these stop reports. Whenever it has been more than 2 min since the last location report, an additional location report is sent. This information is sent to the dispatch center operated by Downeast Transportation.

Selected major stops are equipped with DMSs that display text, including the expected departure time of the next bus. The specific equipped stops are located at the Village Green in Bar Harbor, the ANP Visitors Center in Hull's Cove, Jordan Pond House in ANP, and Sand Beach in ANP. Implementation for the Sand Beach sign was not expected until early 2003, in conjunction with construction of a new pavilion structure. For the Visitors Center, Jordan Pond, and Sand Beach signs, the stop serves only a single route, and the sign reports on the next buses inbound and outbound. For the Village Green, the major transfer point, a larger sign has been provided with enough text lines to report on the estimated departure time for the next outbound bus on all routes.

The method for predicting the expected departure time for the sign-equipped stops is based on the current schedule adherence status of the incoming bus. When a bus departs from a stop, its schedule adherence is reported to the dispatcher and used to update the downstream next departure displays. If a bus is running early, it is expected that the driver will wait at the next stop to restore schedule adherence. Thus, the next departure sign is still based on the schedule. However, if a bus is running behind schedule, the time displayed on the sign is estimated using an algorithm that calculates if the bus is expected to recover any of the delay. Such makeup time is based on the portion of scheduled layovers that can be used for schedule recovery and any preplanned capacity to recover time enroute.

In the first season of operation, summer 2002, the AVL and real-time bus arrival information systems were very successful. Several riders commented on the DMSs as part of a survey that was conducted on August 7 and 9, 2002, to measure rider satisfaction with the IE service [http://www.exploreacadia.com/surv02_1.pdf (as of December 2002)].