CHAPTER THREE

TECHNICAL CHARACTERISTICS OF REAL-TIME BUS ARRIVAL INFORMATION SYSTEMS

UNDERLYING AUTOMATIC VEHICLE LOCATION TECHNOLOGY

The synthesis survey covered several key characteristics of the responding agencies' real-time bus arrival information systems (see Appendix B for a list of the responding agencies). The underlying technology, which is an AVL system, is necessary for determining real-time arrival information. AVL systems provide information on the location of each bus and sometimes other critical information, such as vehicle speed and direction, and schedule adherence.

As of 2000, 88 transit agencies in the United States had operational AVL systems, and 142 were planning such systems, making AVL one of the most deployed ITS systems in the transit industry. Of the 88 deployed systems, 65 are in the 78 largest U.S. metropolitan areas. From 1995 to 2000 there was a 300% increase in agencies with operational systems (*5*). Because of the number of existing and planned deployments in the United States, this underlying technology will make it possible for many agencies to consider deploying real-time bus arrival information systems that may not have considered it before. This possibility is reflected in that in 2000, there were 291 operational automated transit information systems in the United States, with 48 more planned. Real-time bus arrival information systems accounted for some of these automated transit information systems, in addition to other pretrip, wayside, and in-vehicle systems.

Furthermore, "the use of AVL in public transit has been slower in the U.S. than in Canada and Europe. The first demonstration of AVL in Europe was in Hamburg, Germany in 1964" (*6*, p. 4). European countries have deployed a greater number of real-time bus arrival information systems than the United States, and they deployed them earlier.

Table 1 shows, for each responding agency, the number of vehicles equipped with AVL systems. Table 1 also shows that most responding agencies are using either Global Positioning System (GPS)-based AVL technology or differential GPS (DGPS)-based AVL technology, which provides better location accuracy than GPS, as their primary method for determining vehicle location. In addition, two signpost systems are listed in Table 1. These are signpost/beacon systems, in which each bus sends location and/or odometer data to dispatch. Across all respondents, location information on each vehicle is updated—transmitted from each vehicle to a central location—with a frequency of 30 s to 5 min. The frequency of location update is critical to the accuracy of the real-time arrival predictions, which use vehicle location as one of their key inputs.

Besides providing necessary information to real-time bus arrival information systems, AVL systems afford many operational benefits and can be integrated with other ITS systems to provide vital information (e.g., automatic passenger counters) and control vehicle operation (e.g., transit signal priority). These benefits include facilitating the analysis of transit service performance in real time and historically; collecting information needed to perform system planning, such as running times, and scheduling; and providing vehicle locations to emergency management.

REAL-TIME INFORMATION DISTRIBUTION

The most prevalent medium used for the distribution of real-time bus arrival information is the electronic sign, also known as a dynamic message sign (DMS), located at a bus stop. Of those agencies surveyed, there were a total of 98 signs located at bus stops in the United States and 1,981 signs located at bus stops among the non-U.S. respondents. Of all the types of electronic signs available, the light-emitting diode (LED) sign is the most prevalent, with the liquid crystal display (LCD) signs being next most frequently used.

Figure 1 is a photograph of a real-time bus arrival LED sign being used at 11 Portland Tri-Met (Tri-County Metropolitan District of Oregon) bus stops. Figure 2 shows an LED sign being used at Los Angeles County Metropolitan Transportation Authority (LACMTA) Metro Rapid bus stops. Figure 3 shows a Countdown LED sign at a London Buses bus stop near the Hammersmith London Underground stop. Figure 4 shows a bus stop sign in Rome, Italy. This sign not only shows real-time bus arrival information (in English and Italian), but it has a static stick map of the bus route.

Figure 5 shows a unique system used by City Bus in Williamsport, Pennsylvania, which does not actually display real-time bus arrival information, but provides the real-time location (bus bay) of each bus within the transit

TABLE 1
UNDERLYING AUTOMATIC VEHICLE LOCATION (AVL) TECHNOLOGY INFORMATION

Agency	No. of AVL-Equipped Vehicles	Total No. of Vehicles	Type of AVL	Frequency of Location Update (in min)
City Bus (Williamsport, Penn.)	25	25	GPS	5.0
Delaware Transit Corporation (DTC) (Wilmington, Del.)	189	189	GPS	1.0
Fairfax City–University–Energysaver (CUE) (Fairfax, Va.)	12	12	GPS	0.5
Glendale Beeline (Glendale, Calif.)	20	35	GPS	1.5 or every 200 m
King County Metro (Seattle, Wash.)	1,300	1,300	Signpost	1.0 to 3.0
Los Angeles DOT (LADOT)/Los Angeles County Metropolitan Transportation Authority (LACMTA)—Metro Rapid System (Los Angeles, Calif.)	150	150	Transponder to inductive loop system	1.0
Regional Transportation District (RTD) (Denver, Colo.)	1,111	1,111	GPS	2.0
San Francisco Muni (San Francisco, Calif.)	827	827	GPS	1.5
Tri-County Metropolitan Transportation District of Oregon (Tri-Met) (Portland, Ore.)	689	689	GPS	1.33–1.5
ATC Bologna (Bologna, Italy)	450	976	GPS	0.5
Centro (Birmingham, U.K.)	6	NR	GPS	0.5
Dublin Bus (Dublin, Ireland)	156	1,062	GPS	0.5
Kaohsiung (Taiwan)	250	500	GPS	0.5
Taichung (Taiwan)	250	480	GPS	0.5
Taipei (Taiwan)	135	3,808	GPS	0.5
Kent County Council (Kent, U.K.)	141	700	DGPS	0.5
Transport for London—London Bus Services Limited (London Buses) (London, U.K.)	5,700	6,600	Signpost	0.5
YTV (Helsinki Metropolitan Area Council) (Helsinki, Finland)	340	550	DGPS and Signpost	0.5

Notes: GPS = Global Positioning System; DGPS = differential GPS; NR = not reported.

FIGURE 1 Portland, Oregon, Tri-Met Transit tracker sign.

FIGURE 2 Los Angeles Department of Transportation/Los Angeles County Metropolitan Transportation Authority Metro Rapid Bus stop shelter sign.

FIGURE 3 London Buses Countdown sign.

center. This system contains both dynamic signage and audio information that helps transit riders identify the locations of their desired bus routes. Information on the signs and in the audio messages uses data received from mobile data terminals (MDTs), which are installed in all 28 of City Bus' vehicles. When drivers arrive at the transit center, they use the MDT to indicate that they have entered the terminal, as well as their stop and route numbers. These data are then sent to the base control computer in the transit center via a wireless local area network modem. The data are used to build visual and audio messages, and are stored in a database for future analysis. The text messages are displayed on signs inside and outside of the bus, and in corresponding audio messages that are broadcast over the public address system. Drivers have the ability to revise information if an error occurs or if they use a different bus bay than the one originally indicated. Announcements over the public address system include the bus route and the bus stop location, and they are repeated every minute while the bus is in the terminal.

A unique system that is being developed to provide bus operations personnel (not customers) with real-time arrival information uses an electronic toll tag. This project, which was expected to be operationally tested in the spring of 2003, can be described as follows. The Transportation Operations Coordinating Committee, known as TRANSCOM, implemented the System for Managing Incidents and Traffic (TRANSMIT). The committee is a consortium of highway, transit, and public safety agencies in the New York City metropolitan area, including New York, New Jersey, and Connecticut. TRANSMIT uses vehicles equipped with electronic toll tags as anonymous probes to manage traffic and to provide traveler information.

> Transponder readers installed along roadways detect EZ-Pass [electronic toll collection system in New York and New Jersey] tags and scramble tag ID's for privacy. As tags are detected by successive readers, the TRANSMIT system compiles aggregate data on average speeds, travel times, and the number of non-arriving vehicles (expected vehicles not yet detected by the next reader downstream). By comparing this information to historical data, TRANSMIT can detect incidents and alert the member agencies' operations centers for response. TRANSMIT has been implemented on over 100 miles of toll and non-toll roadway in Rockland, Westchester, Bronx, Kings, Queens, Richmond, and New York counties in New York, and Bergen, Hudson, Middlesex, and Union counties in New Jersey (*7*).

An application of TRANSMIT is being developed for New Jersey (NJ) Transit buses that travel to and from the Port Authority Bus Terminal (PABT) in New York City.

FIGURE 4 Bus arrival sign in Rome, Italy.

FIGURE 5 City Bus Transit Centre sign (Williamsport, Pa.).

As currently planned, as NJ Transit buses enter the eastbound approaches to the Lincoln Tunnel and the PABT, TRANSMIT readers over the roadways will read their EZ-Pass tags and compare them with schedule and bus assignment data downloaded from NJ Transit's radio and scheduling systems. The information will then be relayed to NJ Transit personnel at the PABT via wireless PDAs. The personnel will use this information to help expedite afternoon bus departures from the terminal (J.M. Lutin, Intermodal Planning and Capacity Analysis, New Jersey Transit, personal communication, January 2, 2003).

This TRANSMIT application is being evaluated as part of the ITS Program Assessment and Evaluation program by the Federal ITS Joint Program Office (*8*).

One additional method of providing real-time bus information is to display actual vehicle locations on a map of the service area that is available via the Internet and/or kiosks. This method does not provide real-time arrival

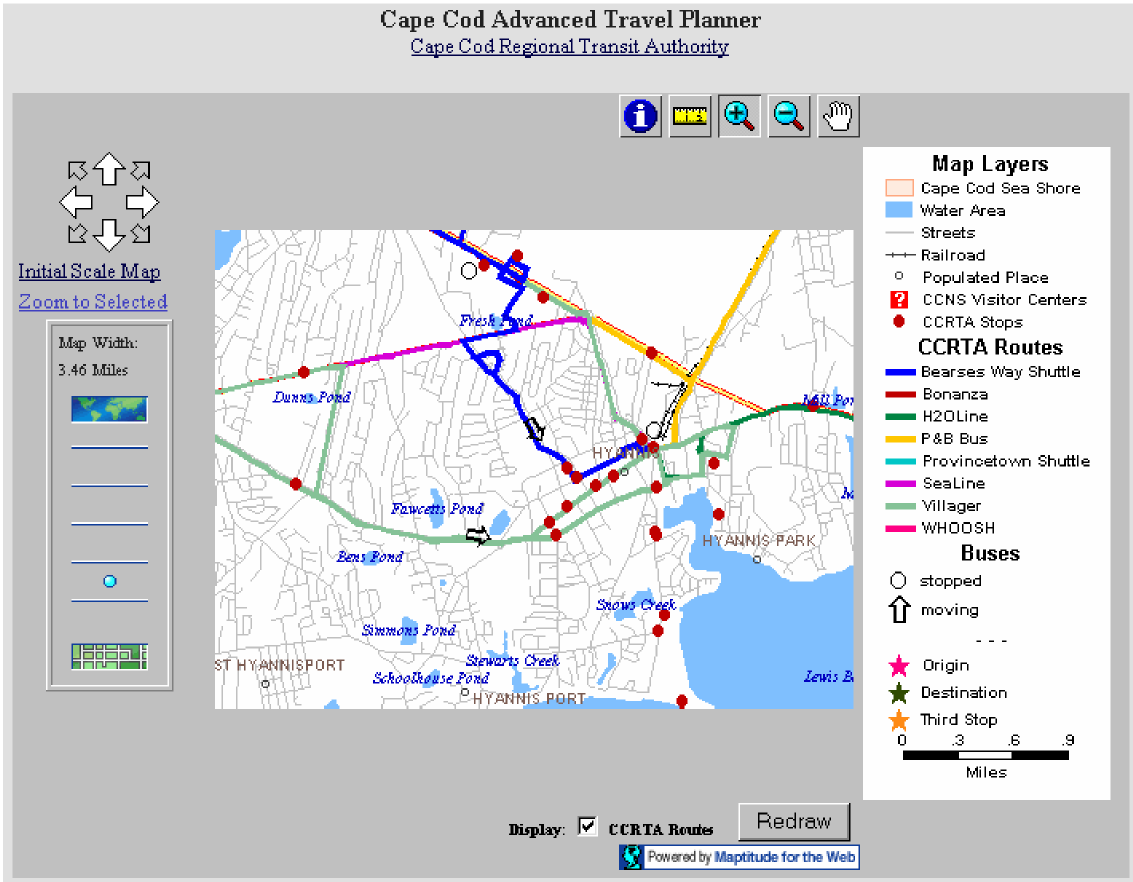


FIGURE 6 Cape Cod Regional Transit Authority (CCRTA) real-time bus location map.

information, but it requires less data and is a visual method to show customers where their vehicles are currently located. One example of this application is available from the Cape Cod Regional Transit Authority via the Internet (http://www.capecodtransit.org), as shown in Figure 6. The current vehicle location and the direction of travel are displayed. Another example combines the real-time vehicle location display with predicted arrival time, as shown in Figure 7. This system, called RideFinder, was deployed by the Central Ohio Transit Authority on kiosks in August 2001. The touch-screen interactive kiosks not only display a map of the hotel airport circulator route with the actual location of the buses and the estimated arrival time of the bus at that stop, but they can be used to access weather information and information on the agency's services and fares. In addition, arrival time is provided in audio format. The visually impaired can simply push a button on the kiosk to hear estimated bus arrival times.

Generally, the following types of information displayed on electronic signs were the most prevalent:

- Current time and date;
- Route number and final destination of vehicle;
- Waiting time, either in countdown format or time range; and
- Service disruptions or other important service messages.

The communications technologies that are used most often to transmit information to electronic signs at bus stops are cellular communications [mostly cellular digital packet data (CDPD)] and conventional telephone lines. Other technologies used less frequently include dedicated short-range communications (e.g., beacons), integrated services digital network lines, and T1 lines (a dedicated telephone connection supporting data rates of 1.544Mbits per second). As mentioned later in this report, having adequate communications coverage in the service area is critical to the success of communicating real-time information to the signs.

Although the survey did not ask respondents specifically about the costs associated with communications and how these costs were funded, the costs are critical and should be included in the budget for operations and maintenance (O&M) once the system is deployed. Furthermore, the use of wireless communication technologies such as CDPD are charged on a monthly basis and are also charged on a "per packet" basis. For example, if an agency uses CDPD to provide communication of real-time arrival information to each DMS, the ongoing communications costs will include charges for each data packet sent to each

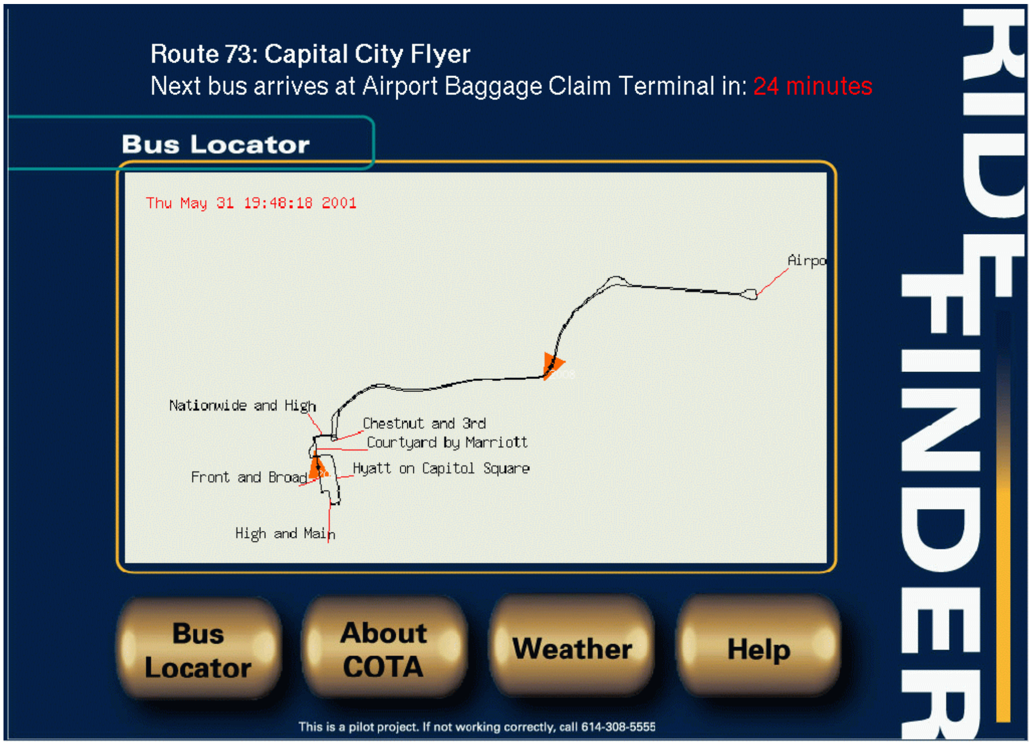


FIGURE 7 RideFinder (Central Ohio Transit Authority) real-time bus location screen.

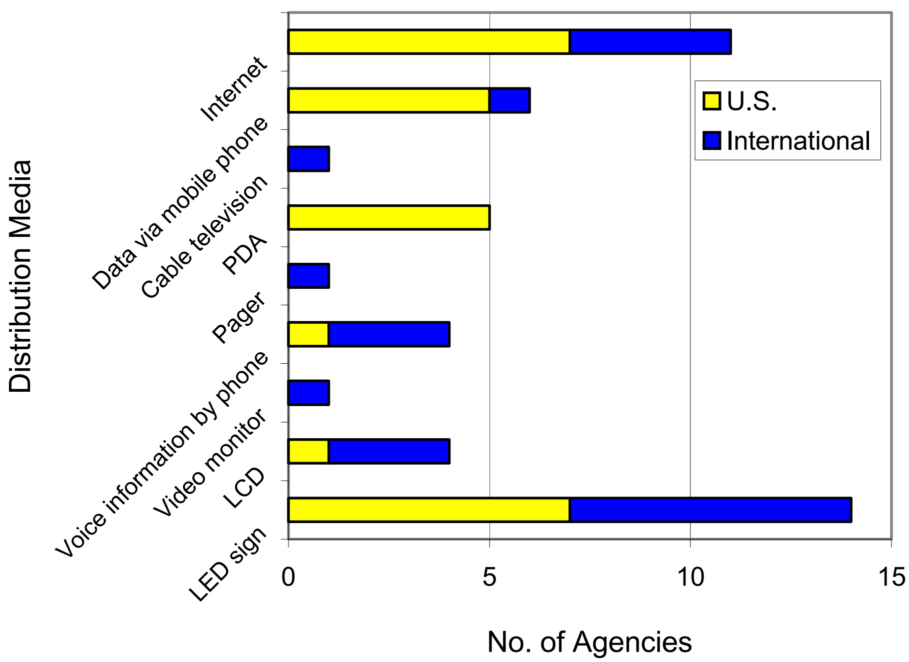


FIGURE 8 Distribution media for real-time bus arrival information.

sign on a monthly basis. If information on each sign is updated at least every minute, the resulting communications charges can be significant.

In addition to electronic signs at bus stops, there are several other types of media being used by the responding agencies to distribute real-time bus arrival information. Seven of the responding U.S. agencies have real-time information available on the Internet, six have real-time information available on PDAs, five on wireless application protocol-enabled mobile telephones, and one using a voice recognition system. Figure 8 provides the distribution media

TABLE 2
INTERNET ADDRESSES FOR REAL-TIME BUS ARRIVAL INFORMATION (as of December 2002)

Agency	Internet Address for Real-Time Bus Arrival Information
DTC (Del.)	http://www.beachbus.com/
Fairfax CUE (Va.)	http://www.ci.fairfax.va.us/Services/CueBus/NextBus.htm
Glendale Beeline (Calif.)	http://www.glendalebeeline.com/
King County Metro (Wash.)	http://www.mybus.org
	http://busview.its.washington.edu/busview_launch.jsp
RTD (Colo.)	http://www.rtd-denver.com
San Francisco Muni	http://www.sfmuni.com/routes/indxrout.htm
Tri-Met (Oreg.)	http://www.tri-met.org/arrivals/index.htm
Centro (Birmingham, U.K.)	To be announced
Kaohsiung (Taiwan)	http://www.mybus.com.tw
Taichung (Taiwan)	http://www.mybus.com.tw
Taipei (Taiwan)	http://www.apts.com.tw
Kent County Council (U.K.)	Internet planned
London Buses	Internet planned
STIB (Brussels, Belgium)	http://www.stib.irisnet.be/FR/36000F.htm

Notes: DTC = Delaware Transit Corporation; CUE = City–University–Energysaver; RTD = Regional Transportation District; Tri-Met = Tri-County Metropolitan Transportation District of Oregon; STIB = Societe des Transports Intercommunaux de Bruxelles.

for the survey respondents. Table 2 shows the Internet address for each respondent using the Internet as one of the distribution media of real-time information.

Société des Transports Intercommunaux de Bruxelles (STIB) (Brussels, Belgium) did not participate in the synthesis survey, but the agency does provide real-time information on their website, as noted in Table 2. STIB provides real-time bus location and arrival information, as shown in Figures 9 and 10. On the first website screen, the user selects the bus route and destination. Then, STIB displays the position of each vehicle (as a solid box) on a stick map of the route showing all stops. The final destination of the bus is displayed in the upper right-hand corner as a reminder. Next, the user can click on any stop along the route to obtain real-time information about when the next bus on the selected route and direction will arrive. Also, the user can display real-time information for all transit services emanating from the selected stop.

Images from several Internet websites that provide real-time bus arrival information are shown in Figures 11 through 13.

REAL-TIME PREDICTIONS, AND PREDICTION ACCURACY AND RELIABILITY

The key to accurate predictions of real-time bus arrival times is two-fold: the prediction algorithm or model, and the data that are used as input to the algorithm. In many cases, the prediction algorithms are proprietary and not typically disclosed by vendors that provide these types of systems. However, this synthesis revealed a number of models that are not proprietary, several of which are currently in use. Four models will be described briefly here.

As part of an FTA Field Operational Test conducted in Blacksburg, Virginia, entitled the Rural Traveler Information System Operational Test, Lin and Zeng developed four GPS-based bus arrival time estimation algorithms (*9*).

> In addition to GPS-based bus location data, other information [was] used as input data, including bus schedule information, bus delay patterns, and bus stop type information (a time-check stop vs. a regular stop). Whereas all algorithms employ GPS-based bus location data, the level of other information used in each algorithm varies (*9*, p. 13).

Lin and Zeng measured the performance of each algorithm using the following criteria: overall precision, robustness, and stability. They determined that the dwell time at time-check stops is most significant to the performance of each algorithm.

The Los Angeles Department of Transportation (LADOT) developed the Bus Arrival Information System that is being used as part of the LACMTA Metro Rapid bus rapid transit system. This system contains a prediction model that operates generally as follows (*10, 11*):

- Records bus arrival time at every bus detector, an inductive loop placed in the roadway, which serves as an antenna to receive the transponder identification code of the bus;
- Estimates bus travel time using previous bus information; and
- Calculates arrival times for approaching buses to all bus stops.

Specifically, Hu and Wong describe the prediction algorithm as follows.

> This system utilizes the loop-transponder technology as an Automatic Vehicle Locator (AVL) to detect and identify bus

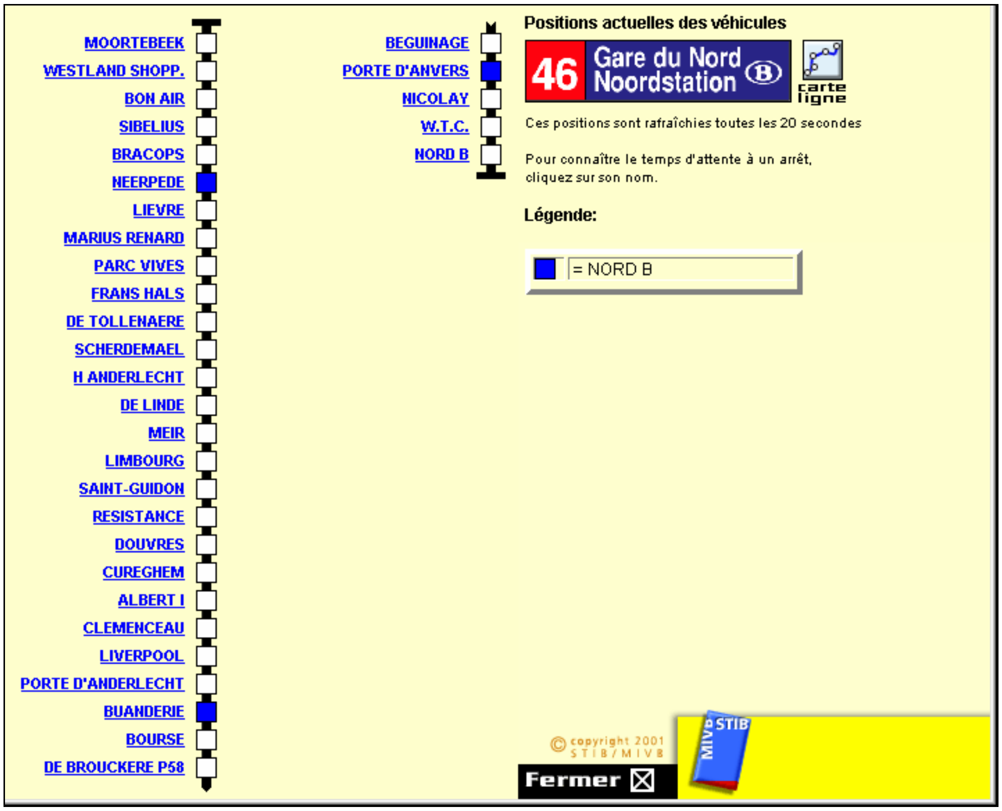
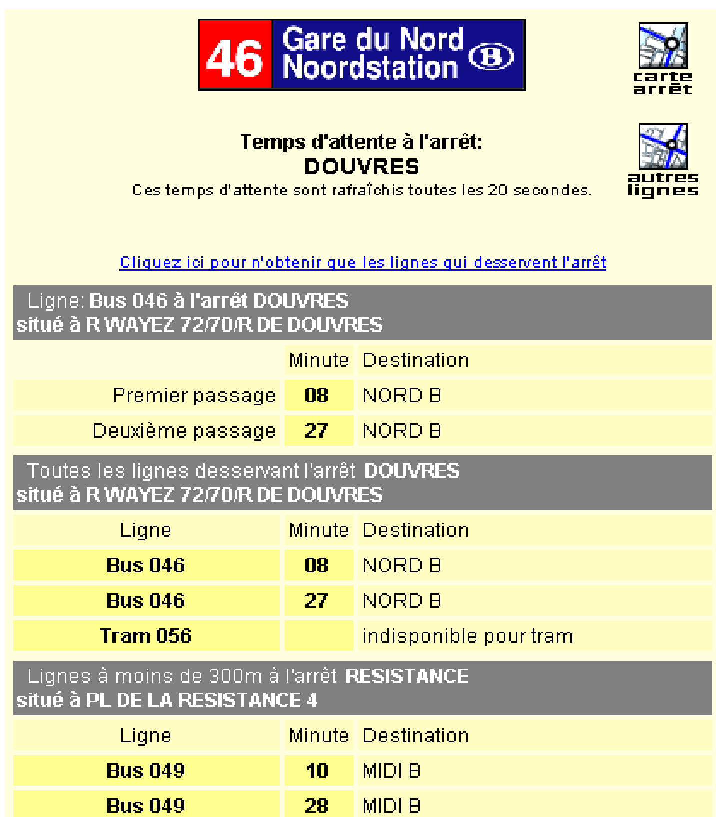


FIGURE 9 Société des Transports Intercommunaux de Bruxelles real-time bus location information (Brussels, Belgium).



46 Gare du Nord Noordstation

carte arrêt

Temps d'attente à l'arrêt:
DOUVRES
Ces temps d'attente sont rafraîchis toutes les 20 secondes.

autres lignes

Cliquez ici pour n'obtenir que les lignes qui desservent l'arrêt

Ligne: **Bus 046 à l'arrêt DOUVRES**
situé à R WAYEZ 72/70/R DE DOUVRES

	Minute	Destination
Premier passage	**08**	NORD B
Deuxième passage	**27**	NORD B

Toutes les lignes desservant l'arrêt **DOUVRES**
situé à R WAYEZ 72/70/R DE DOUVRES

Ligne	Minute	Destination
Bus 046	**08**	NORD B
Bus 046	**27**	NORD B
Tram 056		indisponible pour tram

Lignes à moins de 300m à l'arrêt **RESISTANCE**
situé à PL DE LA RESISTANCE 4

Ligne	Minute	Destination
Bus 049	**10**	MIDI B
Bus 049	**28**	MIDI B

FIGURE 10 Société des Transports Intercommunaux de Bruxelles real-time arrival information at the Douvres stop on Line 46.

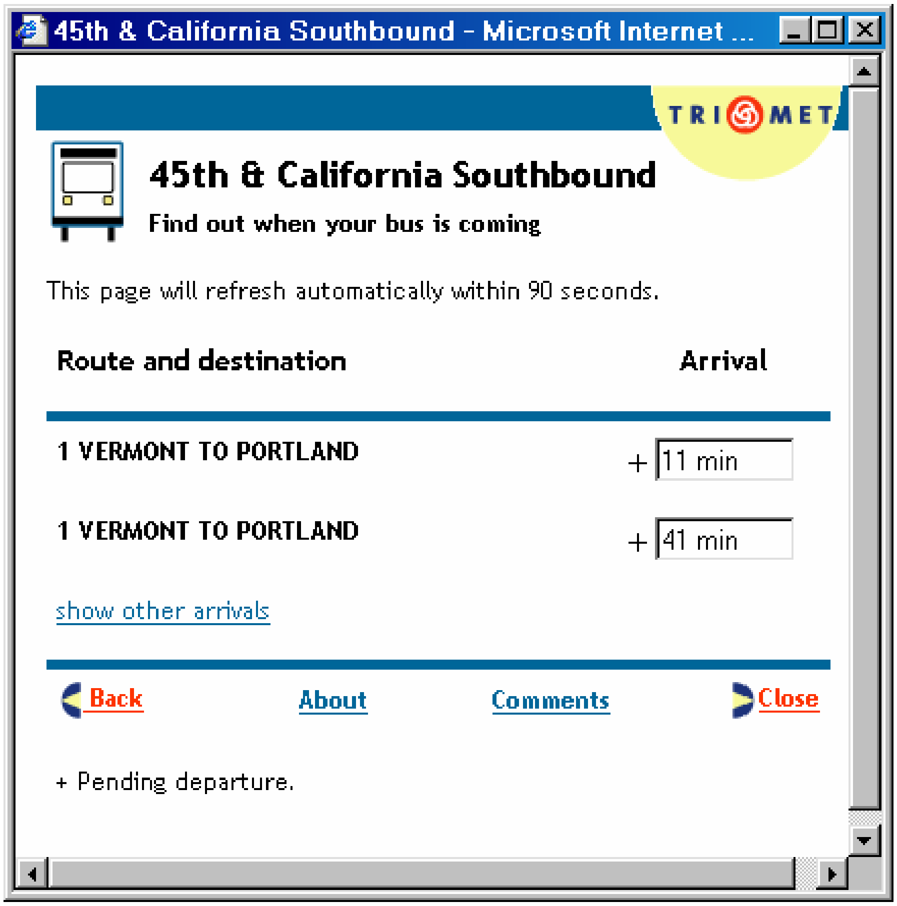


FIGURE 11 Tri-Met Transit Tracker on the Internet.

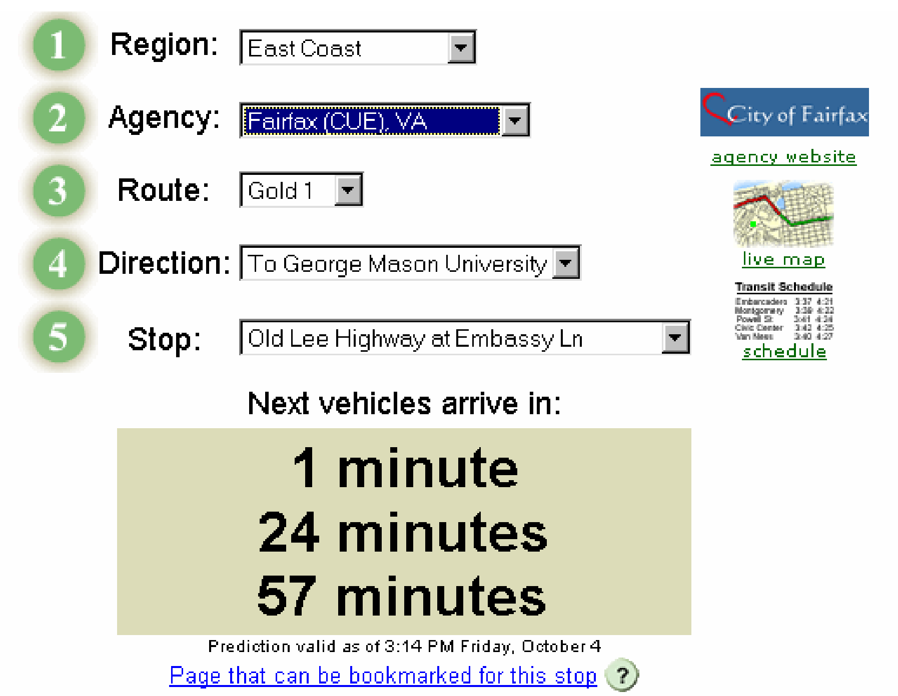


FIGURE 12 Fairfax CUE (City–University–Energysaver) real-time information.

37 AV SW & SW ALASKA ST(farside)

MyBus WAP site: www.mybus.org/wml/
This Metro location is number 6055

Last Updated: Fri Oct 04 11:12:32 PDT 2002

Show Location List | Show Location Map

Route	Destination	Scheduled	Depart Status
22	Downtown Seattle	11:21am	1 Min Delay
22	White Center	11:23am	On Time
51	West Seattle Junctn	11:29am	No Info
54	Downtown Seattle	11:12am	3 Min Delay
54	Downtown Seattle	11:42am	No Info
54	White Center	11:30am	On Time
55	Admiral District	11:15am	9 Min Delay
55	Downtown Seattle	10:57am	No Info
55	Downtown Seattle	11:27am	On Time
570E	INT. DISTRICT STA. (DOWNTOWN SEATTLE)	11:18am	4 Min Delay
570E	SEA-TAC AIRPORT	11:25am	2 Min Delay

Created by ITS-UW, Data from MetroKC, Funding from Sound Transit

FIGURE 13 King County Metro (Washington State) MyBus information.

> locations. More than 150 Metro Rapid buses are equipped with system transponders and can be detected when passing through any of the 331 loop detectors throughout the two corridors [Wilshire and Ventura Boulevards]. TPM [Transit Priority Manager] first tracks every data that is generated when a bus traverses through a detector in the system. It consists of two real-time lists—the Hot-List (HL) and the Run-List (RL) objects. The HL tracks movement of every bus operating along a TPM corridor, which contains the bus attributes, position, and running status. The RL stores the detail time-point table and detector attributes, including bus scheduled arrival time-points, and actual arrival time-points.
>
> Bus travel time is a function of distance and prevailing bus speed. TPM employs a Dynamic Bus Schedule Table technique (DBST) using an innovative algorithm approach called the Time Point Propagation (TPP) method, which dynamically builds the Schedule Arrival Time Point table with runtime information from the prior bus arrival time for the same locations plus the active headway value of the current bus.
>
> The actual arrival time-point is also used for the prediction of Estimated Time of Arrival (ETA) of the next bus. ETA is calculated based on the previous bus travel time under the assumption that the current bus would experience the same or similar traffic conditions in the same segment of the corridor. The predicted bus arrival information is then transmitted through Cellular Digital Packet Data (CDPD) services to LED display signs at major bus stations. According to a field survey, the accuracy of the bus arrival information is relatively high (*11*).

Dailey et al. (*12*) created the prediction algorithm that is used by King County Metro to provide real-time bus arrival information via the Internet and mobile telephone, and on LCD displays at the Northgate Transit Center. Also, this algorithm was used to demonstrate the prediction of arrivals for Portland Tri-Met vehicles (*13*). In this algorithm, "the time series, consisting of time and location pairs, is used with historical statistics in an optimal filtering framework [Kalman filter] to predict future arrivals" (*12,* p. 1). According to the authors, seven assumptions drive the algorithm, as follows:

> 1. Vehicle locations are available irregularly, typically on a one- to five-minute basis;
> 2. Each scheduled trip is a realization of the stochastic process of the vehicle traveling the route;
> 3. The stochastic process is represented by the ensemble of realizations;
> 4. Vehicles are modeled as if moving with constant speed over a limited distance;
> 5. Starting and stopping motions of the vehicles are included in the variability of the process model;
> 6. The variability of the process model is normally distributed; and
> 7. There are known errors in the measurement of the location of the vehicles.
>
> These assumptions allow the problem to be formulated in a statistical framework and fulfill the requirements necessary to use the Kalman filter to make optimal estimates of the predicted time until arrival for individual vehicles (*12*, pp. 1–2).

Welch and Bishop describe the filter this way: "The Kalman filter is a set of mathematical equations that provide an efficient computational (recursive) solution of the least-squares method. The filter is very powerful in several aspects: it supports estimations of past, present, and even future states, and it can do so even when the precise nature of the modeled system is unknown" (*14*).

Puckett and Honkus (*15*) describe a demonstration in Houston, Texas, in which arrival times for one Houston Metro bus route were displayed on a device located at one transit center and were made available on the Internet. Commercial off-the-shelf (COTS) GPS and CDPD devices were used along with a database containing vehicle locations. The location data in the database were then used together with

> stored bus stop information in order to place the vehicle on the appropriate route and update another database with average running times between stops. This second database separated the average running times by day of week and hour of the day. Finally, an Active Server Page was created that generated an automatically updated web page that could be accessed from any machine or device with an Internet connection. The page determined from the running time database, the closest vehicle in either direction and from its current time and location, computed the sum of the average running times to the Transit Center and furnished that information to the page. The update was furnished every minute. The entire computation process was tested over a two-month period. With only minor adjustments in the first few days, the computation and display performed flawlessly (*15*, p. 171).

However, after the conclusion of this demonstration, Houston Metro decided not to fully deploy this system for a variety of reasons, among which were that all Metro buses would have to be equipped with AVL and related communications hardware and software for the system to be effective across the whole Metro system. Furthermore, with the current procurement of its Intelligent Vehicle Operation and Management System, Houston Metro was waiting to examine the cost of using this approach with the hardware and software that would be procured.

As mentioned earlier, several real-time prediction models are proprietary. In addition, one vendor of real-time bus arrival information systems has been issued a patent entitled "Public Transit Vehicle Arrival Information System" that "describes a method for notifying passengers waiting for public transit vehicles of the status of the vehicles, including the arrival times of vehicles at stops" (*16*). In 2001, this patent was the subject of legal actions between the vendor and other providers of real-time bus arrival information systems. All legal actions to date have been settled. However, the situation raises the issue of whether or not the patent holder has an advantage in the industry, and other legal actions may be taken in the future because of the presence of this patent.

Furthermore, another similar patent had previously been issued to an ITS vendor not usually thought of as being in the real-time bus arrival information systems business entitled "Method and Apparatus for Determining Expected Time of Arrival" (*17*). Through 2002, there had been no legal actions related to that patent.

A variety of data is used as input to the aforementioned models. Beyond the typical input, which pertains to vehicle location, other data can be used and may affect the accuracy of the predictions, including

- Current traffic conditions (e.g., real-time traffic speeds);
- Real-time operating data from the last several buses on a particular route that passed a specific stop (e.g., running time between stops);
- Historical traffic conditions (e.g., traffic speeds by day and time of day in the past); and
- Historical bus operations data (e.g., running times between specific timepoints by day and time of day).

Table 3 summarizes the type of input data used by the survey respondents.

TABLE 3
PREDICTION MODELS FOR INPUT DATA

Type of Input Data	No. of U.S. Respondents	No. of International Respondents
Current traffic conditions	4	0
Real-time bus operating data	5	5
Historical traffic conditions	4	1
Historical bus operations	5	3
Schedules corrected by current deviation information	1	

Prediction accuracy is measured in a variety of ways. Some agencies monitor both the AVL and real-time arrival information systems directly (usually from a central location) to determine the accuracy of the predictions. For example, a dispatcher or specially designed software could monitor vehicle locations and predicted arrival times to determine if the predictions are accurate. This monitoring can take place either in real time or historically, using data logs from the signs and/or central system. Other agencies conduct field visits to compare actual bus arrival times with the times depicted on the dissemination media. Several agencies do not monitor prediction accuracy at all. One agency reported that it measures the variation in predicted arrival time for specific prediction times (e.g., when the prediction is that the bus will arrive in 10, 5, and 2 minutes). Furthermore, that agency determines the number of accurate predictions within plus or minus 25% of the displayed predictions.

Monitoring accuracy can be used as a way to determine if any predicted data should be provided to the customer. For example, London Buses reported that if AVL performance drops below 65% (because a driver did not log on to the system or buses were not yet equipped with AVL technology), a route will be removed from the Countdown sign, and a message displayed on the sign will indicate that the route is currently not available. The AVL technology has to perform consistently at 80% before the route is displayed on a sign.

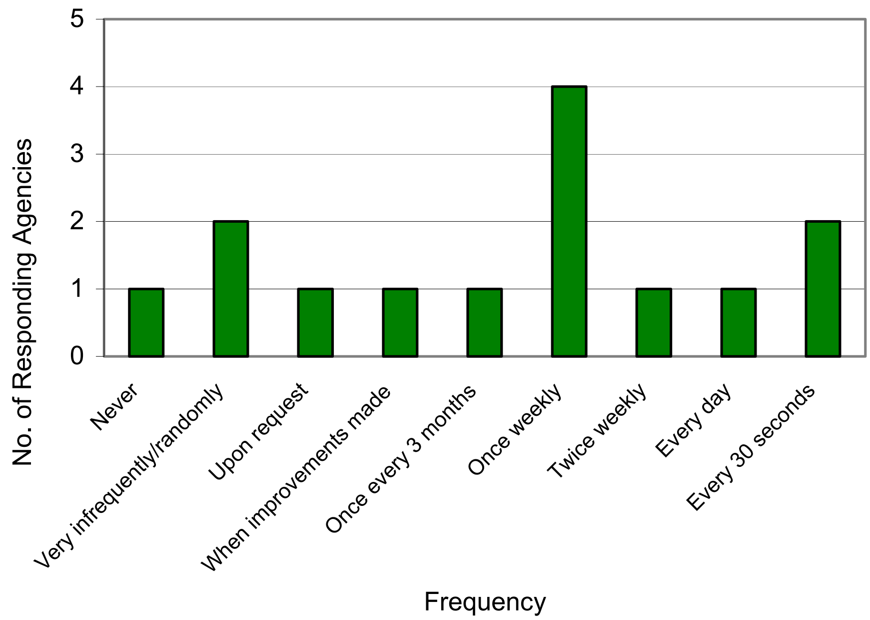


FIGURE 14 Frequency of monitoring information accuracy during regular operation.

The frequency with which prediction accuracy is monitored varies widely among the agencies surveyed, as shown in Figure 14. Most agencies reported that they checked the accuracy exhaustively during the installation and testing phases of their systems, but less frequently during regular operation.

In the synthesis survey, several questions were asked about the reliability of the real-time arrival information. Because several agencies consider accuracy and reliability to be the same, they did not answer those questions about reliability. However, the distinction between accuracy and reliability is an important one: accuracy refers to whether or not the information presented is correct, and reliability refers to whether or not the information is presented consistently (e.g., updated on a regular basis to be timely). Given the perceptions of some survey respondents as to the distinction between these terms, the reliability of real-time bus arrival information systems could be the subject of further study.

USE OF THE INFORMATION GENERATED BY THE SYSTEM

One of the primary concerns about deploying various types of transit technology is being able to effectively use the information that is generated by each technology. For example, some agencies that deploy AVL systems do not fully use all of this information to better plan their services. To better understand how agencies that have deployed real-time bus arrival information systems are using the information generated by the systems—beyond providing the information to the public—the following specific survey question was asked: "How do you use the real-time arrival information?"

In general, it was found that the information is used to optimize the transit service and operations. The use of the information can result in the modification of service frequency, an increase or decrease in the number of buses needed, and/or a better distribution of transit vehicles within the schedule to more closely meet the travel demand.

Of the nine U.S. responses, four agencies reported using the data to perform general transit planning, which can include operations, service, financial, and management planning, and to develop new services; three to change route headways and/or schedules; two to modify route structures; one to increase or decrease the number of buses serving a route; and one to plan new services. Other uses of the data reported by U.S. agencies included monitoring driver behavior, researching customer comments, and monitoring drivers and contractors.

Of the nine international responses, three use the data to perform general planning, three to change route headways and/or schedules, and two to increase or decrease the number of buses serving a route. Other uses of the data reported by responding international agencies include improving bus reliability, expanding the system to other routes, and doing real-time dispatching.