Use of Electronic Passenger Information Signage in Transit

DETAILS

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TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP SYNTHESIS 104

Use of Electronic Passenger Information Signage in Transit

A Synthesis of Transit Practice

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TRANSIT COOPERATIVE RESEARCH PROGRAM

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Cover figure (Left): Washington Metro rail sign. *Credit* Carol Schweiger, TranSystems Corporation.

Cover figure (Right): Bus shelter sign. *Credit* David Phillips, TranSystems Corporation.

FOREWORD

Transit administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the transit industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire transit community, the Transit Cooperative Research Program Oversight and Project Selection (TOPS) Committee authorized the Transportation Research Board to undertake a continuing study. This study, TCRP Project J-7, "Synthesis of Information Related to Transit Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute a TCRP report series, *Synthesis of Transit Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Donna L. Vlasak
Senior Program Officer
Transportation Research Board

This synthesis documents the state of the practice on the use of electronic passenger information signage using the following five elements: underlying technology, sign technology, characteristics of the information, resources required, and decision process used to determine its use.

While agencies seem to be taking full advantage of almost universal access to the Internet and high mobile phone ownership rates to provide their information through these media, providing information by means of electronic signs is seen to provide an added benefit to users. It is easier to look at the sign than getting your mobile device, opening up the application, and searching for the information.

A review of the literature revealed a wealth of information, covering both U.S. and international experience, which is reported in detail. The survey conducted as part of this synthesis, covering the five elements mentioned earlier, was sent to 37 transit agencies around the world and 37 responses were received, a 100% response rate. Case examples offer more in-depth detailed information about practices at the Tri-County Metropolitan Transportation District of Oregon, Real-Time Information Group in the United Kingdom, the Chicago Transit Authority in Illinois, and Mobility Lab in Virginia.

Carol L. Schweiger, TranSystems Corporation, Boston, Massachusetts, collected and synthesized the information and wrote the report, under the guidance of a panel of experts in the subject area. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

USE OF ELECTRONIC PASSENGER INFORMATION SIGNAGE IN TRANSIT

SUMMARY

Before technological improvements provided easy access to the Internet and, more recently, available mobile devices, public transit authorities considered electronic signs as the first step in providing both static and real-time information to passengers at stops and stations. According to *TCRP Synthesis 48: Real-time Bus Arrival Information* (2003), "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." As of 2012, DMS deployment was growing rapidly throughout the United States and abroad as a result of positive customer reactions to real-time information and the prospect of increasing ridership because of sign implementation.

In recent years, agencies have been taking full advantage of almost universal access to the Internet and high mobile phone ownership rates to provide information through these media in addition to electronic signage. From *TCRP Synthesis 91* (2011), "The demographics of transit riders have changed significantly over the past five years with many more riders and non-riders using cell phones or even smartphones, which provide Internet access and other capabilities such as mobile e-mail and application programs. This has prompted transit agencies to look beyond providing information by means of traditional dissemination media such as dynamic message signs (DMS), which require more resources to implement (e.g., cost for installation, power, communication, and maintenance). At the same time, agencies' capabilities to provide real-time information have grown considerably with many agencies deploying technologies that allow them to provide customers with real-time information, such as when the next vehicles will arrive at a particular stop or station." Further, although current customer expectations for real-time information on mobile phones and smartphones have prompted many agencies to focus on meeting these high expectations through mobile device applications, electronic signage is still considered an extremely valuable dissemination media. Providing information on electronic signs has an added benefit for users: it is easier to look at the sign than to take out a mobile phone, open the application, and searching for the information.

Finally, the capital and operations and maintenance costs associated with deploying electronic signage has encouraged some agencies to either move away from electronic signage or seek more cost-effective approaches. At the same time, the costs associated with providing information on mobile devices were not fully understood, so agencies did not really know which was more cost-effective: providing information on electronic signage or on mobile devices.

However, agencies also have recognized that not all of their customers carry mobile phones or smartphones, and these mobile devices can have limited use because of the availability of cellular communication networks; therefore, information provided on these devices needed to also be provided on other media such as electronic signs. Also, opportunities for implementing better, more cost-effective signage became possible owing to more full-screen displays [e.g., the availability of liquid crystal display (LCD), which allows more information than is available on older light-emitting diode (LED) signs to be presented to customers]. Further, agencies' deployment of open data (defined as transit

schedule or real-time data made available to the public) allows for organizations beyond transit agencies to deploy signage displaying passenger information—providing opportunities for the private sector. For example, in 2010, in an ice cream shop in Jamaica Plain (just outside Boston, Massachusetts), Benjamin Resner, a software engineer and entrepreneur, designed and built an LED sign for $350 in materials and an afternoon's work. He was interested in providing real-time information about Massachusetts Bay Transportation Authority (MBTA) bus service outside the shop. The sign is "mounted above a display case, to the left of the ice cream counter and the right of the life-sized cow. In red letters that scroll across the face, it displays arrival times for the next two buses." Another example is the work of Mobility Lab in the Washington, D.C., area, which is described in chapter six.

In summary, based on the survey results and the author's experience, agencies are exploring all possible means of disseminating transit information, including considering the deployment of electronic signage. This Synthesis explores the current state of the practice in electronic signage, which is being influenced by three factors: (1) the increased use of mobile media that could be used to provide transit information; (2) agencies increasingly providing "open data" allowing for the development of third-party transit information applications; and (3) the infrastructure requirements and operations and maintenance concerns regarding the electronic signs. The first two factors do not always consider "information equity," which is defined as providing real-time information through at least two dissemination media, and in both audio and visual formats. The third factor indicates that there are recurring costs, which many agencies are trying to minimize. Further, the third factor includes accommodating persons with disabilities, which is defined generally for electronic signage at the federal level [e.g., Sections 218 and 810 of the Americans with Disabilities Act Accessibility Guidelines (ADAAG)]. For example, many agencies may not be aware that the ADAAG contains guidelines for mounting signs at a height to ensure the legibility of the sign. Another example is that some agencies are considering and designing an audio feature into the signs, meaning that the visual information will be provided in an alternate format for visually impaired customers.

This Synthesis examines and documents the state of the practice in the use of electronic passenger information signage in transit using the following five elements:

1. The *underlying technology* that is required to generate the information that will be disseminated on the sign. This element covers the required underlying software, hardware, and communications technology.

2. The *sign technology*, including type of display (e.g., LED, LCD) and other characteristics such as what can be displayed using specific display types (e.g., characters only, characters and pictures).

3. The *characteristics of the information* displayed on the signs, including message types, content, format, and accessibility; the use of standards; and the reliability and accuracy of the displayed information.

4. The *resources required* to successfully deploy and manage electronic signage, including capital and operations and maintenance costs, and agency staff requirements.

5. The *decision process* that is used to determine (1) if signage will be deployed; (2) where the signage will be located; and (3) what will be displayed on the signage, as well as the contribution of electronic signage at stops and stations to an overall agency communications strategy, including "information equity."

The Synthesis has the following four key results:

- Electronic signage is a viable and important dissemination media. Benefits that accrue from the deployment of electronic signage include the following (based on the literature review and results of the survey):
  - Providing information that is easy to access once a trip has started (e.g., looking at a sign rather than accessing a mobile phone, running an application and searching for the same information displayed on the sign);
  - Providing information to those customers (and potential customers) who do not have mobile devices or alternate means to obtain the information;
  - Affecting the perception of wait time;
  - Improving the perception of the transit service being provided; and
  - Increasing the feeling of safety and security.
- There are several approaches to presenting transit information on electronic signage, depending on the type of sign deployed and the status of the transit service.
- The capital cost of signage is fairly high, but the cost of newer (e.g., flat panel screens), customizable electronic signs is lower. Further, the use of open data to provide the information displayed on the signage may increase the usability and effectiveness of electronic signage by being able to provide information on more than one transit service.
- Newer sign technology, such as LCD signs, may be able to greatly expand the volume and depth of the information being provided.

The Synthesis produced the following five key conclusions:

- The deployment of electronic signage should be considered as one of several methods to disseminate passenger information, rather than the only method.
- There are opportunities to capitalize on agencies' open data and low-cost, customizable displays—perhaps creating a market for third-party providers to provide signage for a transit agency or a region with multiple transit agencies.
- There is potential to expand the typical information provided on passenger information displays by utilizing full-screen or large touchscreen displays.
- Although information displayed on electronic signage cannot be personalized, the content of messages is extremely important when conveying specific types of events.
- A plan for measuring and monitoring the accuracy, reliability, and timeliness of messages, which several responding agencies are developing, is an important element of deploying electronic signage.

Items for future study include the following:

- The amount of staff time required for successful implementation and ongoing operations and maintenance is not well understood. Thus, a study that examines the amount of time required by various departments and staff is recommended. Further, a discussion of the associated operations and maintenance costs could be covered as well.
- A "model" that agencies could use to determine the "business case" for deploying electronic signage would be helpful.
- More guidance is needed for providing an audio version of an electronic sign display.
- More in-depth information regarding how to determine the content of messages displayed on electronic signage would be helpful for agencies deploying electronic signage.
- More guidance is needed regarding accessibility issues, such as best practices in providing information displayed on signage in audio format.
- More information is needed to explore other ways of providing power to electronic signs, such as solar power.

CHAPTER ONE

INTRODUCTION

PROJECT BACKGROUND AND OBJECTIVES

The primary focus of the Synthesis is on determining the experience that transit agencies have had with deploying electronic signage to provide transit information in the United States and abroad, and the process that agencies are using to decide to deploy information through this dissemination channel to serve the needs of their customers.

In the past 15 years, electronic signage displaying static and real-time transit information has been deployed by transit agencies throughout the United States and abroad. Various sign types [e.g., light-emitting diode (LED), liquid crystal display (LCD)] are available for installation at transit stops and stations, as well as nontraditional locations such as office buildings and shopping malls. Although transit information is increasingly provided on mobile phones and smartphones, agencies recognize that electronic signage has independent utility. Further, because many transit customers do not have mobile devices, electronic signage is an important channel through which vital transit information is conveyed to the public.

Further, as discussed in *TCRP Synthesis 91* (*1*), public transit customers have relatively high expectations for real-time information at all stages of their trips. It has been observed that mobile devices do not always operate in transit stations where there may be no cellular communication coverage. Even if coverage exists, it is faster to look at signage rather than access a mobile phone, open the appropriate application, enter the right information (if necessary), and wait for the results. In addition, electronic signage can provide useful information to customers, resulting in positive customer satisfaction and a potential improvement in the overall agency image. As a result, electronic signage provides the opportunity to provide transit information to customers at stops and stations regardless of mobile device ownership.

This Synthesis examines and documents the state of the practice in the use and deployment of electronic signage using the following five elements. The first is the underlying technology required to generate the information that will be disseminated on the signage. This element covers the required underlying software, hardware, and communications. The second is the signage technology, including the type of display (e.g., LED, LCD) and other characteristics such as the information that can be displayed on specific display types (e.g., characters only, characters and pictures). The third covers the characteristics of the information displayed on the signage, including message types, content, format, and accessibility; the use of standards; and the reliability and accuracy of the displayed information. The fourth covers the resources required to successfully deploy and manage electronic signage, including capital and operations and maintenance costs, and agency staff requirements. The fifth and final element is the decision process that is used to decide if signage will be deployed, where it will be located, and what it will display, as well as the contribution of electronic signage at stops and stations to an overall agency communications strategy, including "information equity." Information equity is defined as providing real-time information through at least two dissemination media, and in both audio and visual formats.

A review of the relevant literature is combined with surveys of selected transit agencies and other appropriate stakeholders in order to report on the current state of the practice. Based on survey results, four case examples or profiles were developed to describe innovative and successful practices, as well as lessons learned and gaps in information.

TECHNICAL APPROACH TO PROJECT

This project was conducted in five major steps. First, a literature review was performed to identify the characteristics of the underlying technology, electronic signage, and information displayed on signage; resources required to deliver information by means of electronic signs; and contribution of electronic signage to an agency's communications strategy. See the References section for a list of references and the Bibliography for the reviewed literature.

Literature Review

This report includes a review of the relevant literature, in addition to the results of a survey that was conducted as part of this project. The survey included items in the five elements described previously, as well as questions regarding their lessons learned in deploying electronic signage. This synthesis also contains the results of interviews with key personnel at selected agencies that have illustrative approaches to deploying and using electronic signage.

The literature review revealed a wealth of material, covering both U.S. and international experience, on the subject of using electronic signs to provide passenger information. The literature review produced five major conclusions. First, current sign technology and the underlying technologies that generate the information displayed on signs allow the deployment of innovative signage. Several recent studies have documented the deployment of large touchscreen signs, some of which allow customer interaction. For example, the Metropolitan Transportation Authority (MTA), New York City Transit (NYCT) recently deployed several "On the Go! Travel Stations," which are 47-inch interactive touchscreens that display "subway notifications, trip planner, subway map [and] continuous ads. [There are] buttons for Service Status, Elevators, MTA Maps, Key Destinations, a Trip Planner, and Planned Work" (*2*). In Brussels, similar devices were installed in several rail stations, allowing customers to explore information on real-time disruptions, train and route schedules, station maps, and rail networks.

Second, the literature describes the use of electronic signage to display multimodal information. Several papers discuss the deployment of signage in California that displays highway and transit travel times, signage at airports that provide real-time transit information to arriving customers, and signage in the Washington, D.C., area that combines real-time information from multiple transit agencies and Capital Bikeshare using open data from each agency.

Third, information content, particularly in the United States, is not well documented. However, the literature on this topic provided detail as to what could be displayed depending on the situation (e.g., normally operating service, disrupted service, cancelled service). Transport for London (TfL) conducted an in-depth study in terms of what information should be displayed and the relative importance of each type of information. And Network Rail in the United Kingdom (U.K.) provides detailed guidance as part of its Operational Information System (OIS) Process Guide (*3*). This guide shows the content of many different types of passenger information displayed on electronic signs throughout the Network Rail system covering systems in England, Scotland, and Wales.

Fourth, making information displayed on signs accessible has been accomplished in the United States and abroad, even though there is limited legal guidance regarding such accessibility. Several reports describe the use of various techniques to announce the information displayed on signs: a button that when pressed will announce what is on the sign, periodic announcements of the display, remote infrared signage, telephones directly connected to a customer service center at the sign location, and touchscreen monitors.

Finally, customer reactions to and perceptions of electronic signage, which are positive, have been studied extensively. Several studies describe how customers perceive the benefits of signage, including a reduction in perceived wait times, reduction in anxiety, increase in safety and security, adjusted travel behavior, and improved attitudes toward transit.

Survey and Survey Results

The survey conducted as part of this Synthesis covered the five elements as mentioned earlier. Surveys were sent to 37 transit agencies around the world; 37 were received, including 5 from Canadian agencies and 5 from European agencies. All responses represent agencies that carry a total of more than 10.75 billion passengers annually, with responding agencies' annual ridership ranging from 1 million (a respondent with fixed-route bus service) to 3.6 billion (TfL).

First, as expected, the top two underlying technologies are computer-aided dispatch (CAD)/automatic vehicle location (AVL) and real-time prediction software that are purchased as part of a CAD/AVL or related system. Among the respondents, 87% of the signs are LED. The top type of information provided on electronic signs is next vehicle arrival/departure prediction time. In terms of sign location, most are located either in a transit station, or at a bus or bus rapid transit (BRT) stop. The characteristics of the signs (e.g., dimensions, number of characters displayed, number lines on the display, colors used) vary greatly depending on the sign type.

Second, the overwhelming reason for deploying electronic signage is to increase customer satisfaction, followed by to supplement other methods of disseminating information. Forty percent of the respondents performed a study to determine whether to deploy electronic signage; of those, the majority conducted a business case analysis. The most prevalent criteria for locating signage was board counts at stops/stations, followed by the availability of power and the number of lines or routes at a station or stop.

Third, the format of the information displayed on a sign varied depending on the type of information and the sign's characteristics (type, number of characters available, etc.). More than 95% of respondents used the Americans with Disabilities Act Accessibility Guidelines (ADAAG) regarding mounting location and height, and slightly more than 90% used the character height guidance to determine the mounting and display characteristics of the electronic signs. Eighty-nine percent of respondents provide information displayed on a sign in audio format. A variety of standards are being used, including the General Transit Feed Specification (GTFS), Transit Communications Interface Profiles (TCIP), Service Interface for Real Time Information (SIRI), and NextBus Public Extensible Markup Language (XML) Feed. In terms of accuracy and reliability, respondents used various methods to monitor these two characteristics.

Fourth, there was a wide variation in resource requirements for deploying electronic signage. Further, the survey responses indicated that some agencies implement signage without knowing the resource requirements. Limited information regarding the actual labor required from specific staff in the organization was reported. Further, little information was reported on operations and maintenance costs.

Finally, in more than 80% of the respondents that have a communication strategy, electronic signage contributes to that strategy. Seventy percent of the respondents consider providing transit information on electronic signage as a way to attract “choice” riders. Just over 65% of the respondents consider information equity. Only one agency has electronic signs that display advertising—in this case, advertising takes precedence over what is displayed on the sign, so real-time information is displayed only in an available “slot” between advertising.

Second, a survey was conducted to collect information on factors such as types of underlying technology; types of electronic signs used; characteristics of the information displayed on the signs, use of standards, and the reliability and accuracy of the displayed information; and necessary resources to deploy electronic signage. The survey also explored information on how electronic signs contribute to an agency’s overall communications strategy. Appendix A contains the survey instrument, and Appendix B contains the list of agencies responding to the survey.

Third, the survey results were documented and summarized. Fourth, telephone interviews were conducted with key personnel at four agencies and organizations that have experience with deploying electronic signs to provide passenger information. Chapter six presents four case examples from selected agencies that have significant experience with implementing electronic signage. Finally, the results and conclusions were prepared and documented.

REPORT ORGANIZATION

This report is organized as follows:

- Chapter one presents the goals and objectives of the Synthesis, and describes the technical approach used to conduct the project.
- Chapter two summarizes the literature review.
- Chapter three describes the underlying technology, sign technology, information displayed on the signage, use of standards, and the reliability and accuracy of the information displayed on the signage.
- Chapter four presents information about the resources needed to deploy electronic signs.
- Chapter five discusses the contribution of electronic signs to an agency’s communications strategy.
- Chapter six presents case examples from selected agencies that have experience implementing electronic signage.
- Chapter seven summarizes the results of the Synthesis, and presents conclusions.
- The References and Bibliography present the literature reviewed.
- Appendix A contains the survey instrument.
- Appendix B shows the list of responding agencies.
- Appendix C shows the total annual ridership for each responding agency.

CHAPTER TWO

LITERATURE REVIEW

The literature review revealed many reports, papers, articles, and press releases that have been written about the use of electronic passenger information signage in transit. This review has the following sections, including the five elements identified in chapter one:

- Underlying technology
- Signage technology
- Information characteristics
- Information accessibility
- Accuracy and reliability
- Monitoring
- Standards
- Required resources
- Decision processes
- Selection criteria
- Signage placement.

The first step of the literature review was to conduct an online Transportation Research Information Services (TRIS) search. This TRIS search yielded more than 100 documents, the most relevant of which were reviewed and used as input to this report. The second step was to obtain and review articles, press releases, and website information directly from agencies and electronic sign vendors across the world. The third step was to review research reports from the FTA, FHWA, and TCRP. Finally, other papers and articles were obtained from different sources, including the following:

- TRB annual meetings,
- APTA conferences,
- ITS America (ITSA) annual meetings,
- ITS World Congress meetings, and
- Internet searches.

The References and Bibliography list all documentation reviewed for the Synthesis.

UNDERLYING TECHNOLOGY

The literature for this element of the research revealed that the technologies that are required to generate the information that is disseminated by means of electronic signage include "automatic vehicle location (AVL) software, computer-aided dispatch (CAD) software, software that calculates the real-time information from data generated by CAD/AVL systems and software" (*1*, p. 9) As stated in *TCRP Synthesis 73* (*4*), an AVL system facilitates the "use of schedule adherence and/or location data to develop real-time predictions for bus arrival times at stops, and providing these predicted arrival times and other service announcements to the public using various methods." Most of these underlying technologies have been the subject of numerous reports and articles, so this Synthesis will describe these technologies briefly in chapter three and provide references to these reports.

Given the coverage of underlying technology in numerous research reports to date, the literature review focused on the most recent developments in generating information that is displayed on electronic signage. First, although AVL systems provide input to algorithms that predict when the next vehicle is going to arrive at a particular stop or station, one of the challenges associated with providing customers with accurate next vehicle predictions is the polling rate of the AVL system. "The polling rate of vehicles is often too infrequent to be of much use for real-time predictions. Many agencies are only able to poll their buses every two to three minutes, which can lead to inaccuracy in real-time arrival predictions. Often there is not enough bandwidth available for transit agencies to transmit vehicle locations at a higher frequency, even if the on-board system can transmit at higher rates" (*5*). Fortunately, many newer AVL systems use higher frequency polls (e.g., 30-second polls), since the cost of the necessary data communication (from vehicle to central dispatch) has been reduced over the past 3 to 4 years (2008–2012).

Similarly, rail control systems that provide information to predict the arrival of rail vehicles must be reliable and accurate. "Data integrity of the core rail and bus operational systems that produce customer information, such as the rail control system, is important. Inaccurate data cannot support reliable customer information systems" (*5*, p. 62).

In the United Kingdom, the Real Time Information Group (RTIG) reports annually on the status of real-time information systems deployment including the underlying technologies that generate the information disseminated through a wide variety of media (*6*). "At the end of 2011, 22,118 buses (50% of the total UK bus fleet of 44,057) were fitted with on-bus tracking units and 3.3 [b]illion (64%) estimated bus passenger journeys occurred on equipped buses. The [real-time information] RTI equipped fleet now accounts for 50% of the UK bus fleet and 51% of the [Great Britain] GB bus fleet" (*6*, p. 11). Figure 1 shows the steady growth in the number of buses equipped with AVL in England since 2002.

FIGURE 1 Number of buses equipped with AVL in England (*6*, p. 17).

Several references discuss the use of underlying technologies to provide electronic signage information about more than one mode of travel. For example, in 2010, electronic signage at John F. Kennedy Airport in Jamaica, NY, was deployed to show passengers real-time information on AirTrain and connecting transit services [Long Island Rail Road (LIRR) and Metropolitan Transit Authority (MTA) New York City Transit subway and bus services]. "The signage displays information about approaching trains, the stops along a particular train's route and what changes may affect the train's service. Officials worked with the companies that operate the AirTrain and provide its SCADA (supervisory control and data acquisition) system to integrate digital signage into the train operations. 'We now have certain triggers that work with the digital signage, so if we go into a bypass strategy the signage gets updated automatically. Now, for example, if it is a train that's stuck and we run a divergent service, all of the information on the digital displays will get updated right away'" (*7*).

Further, at Southampton Airport in Southampton, U.K., real-time multimodal traveler information is provided to arriving passengers on electronic signage. "The travel and transport information system obtains real time traffic and travel information from the Highways Agency, Southampton City Council, Hampshire County Council, South West Trains/Association of Train Operating Companies and Red Funnel Ferries, as well as displaying timetable information for all local bus services and live [closed-circuit television] CCTV images for the local motorway network" (*8*). Figure 2 shows the system architecture.

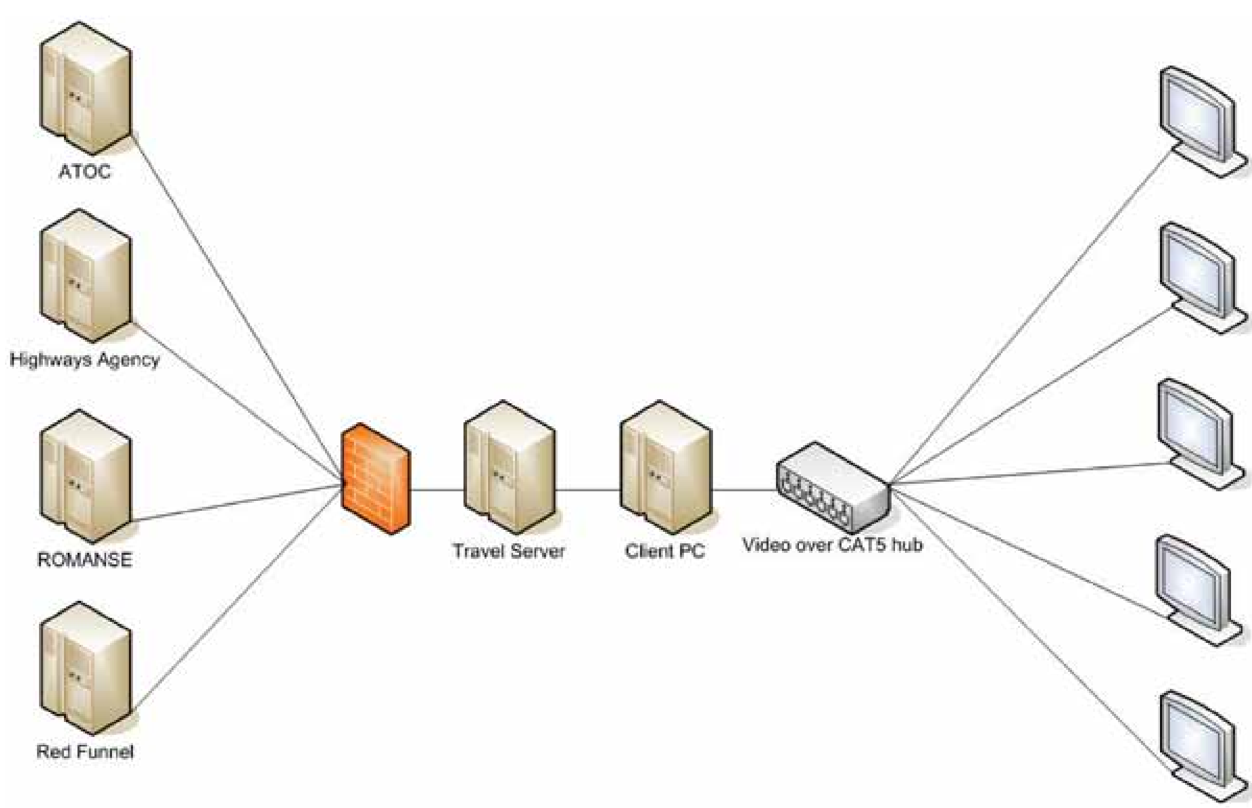

FIGURE 2 Southampton Airport traveler information display system architecture (*8*, p. 5).

Information is obtained from the data providers (shown on the left side of Figure 2) and transferred to the display system using several "standard communications protocols such as XML (eXtensible Markup Language) and Internet protocols such as SOAP (Simple Object Access Protocol). These data are then automatically formatted into a defined standard XML format by adapter software written in Java" (*8*, p. 3). To minimize capital and operational costs, one personal computer is used to send the video to the LCD signs located throughout the airport, rather than using one computer per LCD display. In designing this system, the real-time nature of the information being presented in addition to the environment in which passengers are reviewing this information (e.g., while waiting for and claiming baggage, visiting restaurants and shops) led the system designers to rule out devices that would require passenger input (e.g., kiosks). "Therefore, by utilising large format LCD screens at key locations where passengers are carrying out these other tasks, they can be fed live information on train departures, bus movements and local traffic congestion" (*8*, p. 6).

Less advanced underlying technology was used as part of a demonstration of a transport guidance system in a bus terminal in Tsukuba City near Tokyo, Japan. In this case, "The system combines a system which applies [radio frequency identification] RFID technology in wide use in distribution and an LED display type electronic display board. It detects a bus leaving the bus terminal and updates the display content (the exit/entrance of this bus terminal is one location). On the premise that electric power will be supplied to roadside units, the on-board unit installed on the bus is only an RFID tag, while the road side unit is equipped with a reader/writer" (*9*).

Finally, underlying technology was described as part of the deployment of electronic signage for public transit in Johannesburg, South Africa, before the 2010 Fédération Internationale de Football Association (FIFA) World Cup. In this application of electronic signage for the bus arrival information in bus rapid transit (BRT) stations, an Advanced Public Transport Management System (APTMS) was implemented, consisting of in-vehicle and central fleet management systems. These underlying technologies provide next-bus information (*10*).

SIGNAGE TECHNOLOGY

A considerable amount of literature covers display types (e.g., LED, LCD) and other characteristics such as what can be displayed using specific display types (e.g., characters only, characters and pictures). As summarized in (*5*),

> Intelligent Transportation Systems (ITS) summary deployment statistics from 2006 indicate that roughly thirty percent (30%) of transit agencies in 29 large metropolitan areas surveyed use [dynamic message signs] DMS in locations other than vehicles to disseminate transit routes, schedules, and fare information to customers. DMS, such as light-emitting diode (LED) and liquid crystal display (LCD) systems, show train destination, arrival, and departure information. When placed on loading platforms, they may flash to alert riders of an oncoming train or bus.

In addition,

> [a]gencies across the United States use DMS and LED/LCD monitors to communicate information to customers who are en route, on-board, or at-station. The use of DMS is more likely at heavy and light rail stations or bus depots than at bus stops; although dynamic signs are being introduced at major bus stops as real-time vehicle location information becomes more available. According to 2007 ITS deployment statistics, Alameda-Contra Costa Transit District in California utilizes DMS at 75 of its 6,000 bus stops. In contrast, the Bay Area Rapid Transit uses DMS at all 46 of its rail transit stations and is planning for the installation of in-station LCD screens to increase the type of information travelers receive. (*5*, p. 38)

From Thessaloniki, Greece:

> The most common medium used for the distribution of real time [public transport] PT information, is the electronic display, also known as a Dynamic Message Sign (DMS). The dissemination of real time information is also possible through video monitors, interactive kiosks, personal digital assistants, telephones, Internet, and cable television. Passenger information can be made available on board, through Light Emitting Diodes (LED) and Thin Film Transistor (TFT) technology as well as on the wayside through various display technologies (LED single lines, LED matrix, LED lines, TFT screens). (*11*)

(Note that TFT is a type of LCD display that improves image quality.)

Historically, the early literature (*1*) covering electronic signage for public transit reported that most signs were LED, with LCD technology just beginning to be deployed. Currently, the literature reports a shift to full-screen displays using LCD or plasma technology. For example, in the United Kingdom, the Real Time Information Group (RTIG) reported that "there were approximately 8,130 bus stops fitted with 3-line or multi line LED signs and a further 2,046 fitted with full screen (LCD or plasma displays)" (*6*, p. 22).

As shown in Figure 3, the United Kingdom has a growing number of full-screen displays. This situation is discussed in more detail in chapter five, as this trend is making changes in the information that can be displayed on electronic signs.

> The display type of choice has remained the 3-line/multi line LED type throughout the period 2002–2011. However, there is a long-term trend towards an increasing proportion of screens being full screen. Following a rise in 3-line/multi line LED displays between 2005 and 2008, growth in this display type has mostly remained flat between 2008 and 2011 around the 8,000 display mark.

> Projections for 2012 and 2013 show a sharp increase in 3 line/multi line LED in 2012. Rises in LCD screens will be more modest. The proportion of signs which are 3 line/multi line LED has been at about 80% since 2010 and is expected to continue through 2013 (*6*, p. 22).

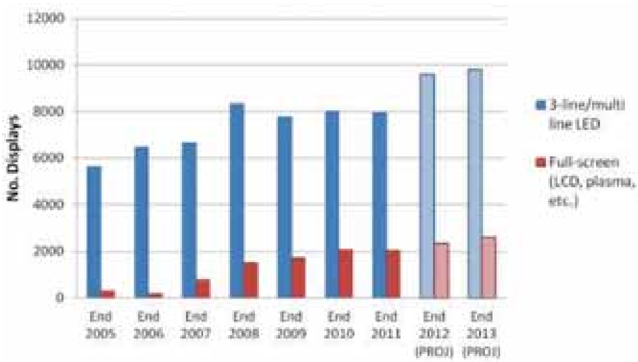

FIGURE 3 Number of electronic signs in Great Britain (*6*, p. 34).

Other systems abroad report the use of both LED and LCD signage. For example, in Milan, 42-inch [diagonal] LCD displays will be replacing the existing LCD displays (see Figure 4) in the subway (*12*).

FIGURE 4 LCD display in Milan subway (*Courtesy*: Carol Schweiger 2008).

In Rennes, France,

> STAR (Service des Transport en commun de l'Agglomération Rennaise) has recently introduced 'INFOSTAR Synchro,' a system that organises real-time information on screens on the platforms of the metro, at the main bus stops, and in the buses themselves. The information is also delivered via voice [to accommodate visually-impaired persons]. 70 screens have been installed on the metro platforms and at the entrances and exits of the ticketing halls in the 15 stations along the metro line. These screens let passengers know when the next two trains will be arriving. Work is underway to equip the busiest bus stops with LCD screens displaying timetable information in real time. The goal is to outfit 260 of Rennes Métropole's more than 1,000 bus stops with these 'passenger information posts.' As with the metro, the screens installed at the bus stops inform voyagers of the arrival times of the next two buses. They can also be informed of any disturbances on the line. Some of which will even be solar-powered. (*13*)

On-board buses, passengers are informed of the following (13):

- The direction of the bus (terminus)
- The four upcoming stops
- Connections with other buses, the metro, or LE vélo STAR (bike-hire system)
- Key public places on the line, such as city halls, hospitals, cultural and sports places, together with economic activity zones and commercial centers
- The time remaining until arriving at the most important stops
- Disturbances
- Availability of LE vélo STAR on the line.

Other types of electronic signage combine various types of display technology. In the Brussels subway, station signs display real-time information, including the route number and destination of the subway along with the number of minutes until arrival and the location of other subways on that same route (see Figure 5). This sign has static (the route and station names on the map) and dynamic elements (dots displayed under the current subway location and the real-time information displayed below the map).

FIGURE 5 Real-time information sign in Brussels subway station (*Courtesy*: Carol Schweiger 2012).

The literature describes several sign systems in the United States and abroad that go well beyond displaying vehicle arrivals and departures—most of these new sign types are large touchscreen computers that allow user interaction. The New York MTA has deployed several 47-inch touchscreen devices called "On the Go! Travel Stations," as shown in Figure 6. "On the Go! Screens were first unveiled in September [2011] at the Bowling Green subway station in lower Manhattan and two major subway complexes: Atlantic Ave.-Pacific St. in Brooklyn and Jackson Heights-Roosevelt Ave. in Queens" (*14*). As of July 2012, the customer acceptance and reception to the signs has not been assessed.

FIGURE 6 MTA On the Go! travel station (*2*).

In Brussels, Belgium, eight large touchscreen monitors have been implemented in two major rail stations: Brussels-Midi and Brussels-Central (see Figures 7, 8, and 9). These 90 × 215 cm touchscreen devices allow users to obtain information about the rail station, real-time service disruptions, and timetables, as well as to plan a trip on the Belgian rail network. They are available in four languages (English, French, Dutch, and German) and are located in high foot-traffic areas. These devices and their use will be evaluated in the future to determine if any changes should be made to the content. To defray the cost of these displays (€17,000 for each two-screen installation), a digital advertising network (including passenger information) using LCD screens is being implemented in the 11 busiest rail stations in Belgium and 22 high-speed rail locations at Brussels-Midi and Antwerp-Central stations. Further, five 4 × 1 m horizontal screens are being introduced to provide advertising and information on weather, tourist opportunities, station activities, and other information of interest to travelers (*15*).

FIGURE 7 Touchscreen inside Brussels–Central Rail Station (*Courtesy*: Carol Schweiger 2012).

Interactive screens similar to those installed in Brussels are being implemented in the Franklin D. Roosevelt metro station in Paris. "At the heart of the new [station] design, passengers will discover two types of screens—16 in all—perfectly integrated into the station. Three x 52-inch (132 cm) touchscreens with voyager information on each platform have replaced the typical paper-based supports. The screens recall a sort of giant iPad, with each one providing the following content:

FIGURE 8 Touchscreen on outdoor platform at Brussels–Midi Rail Station (*Courtesy*: Carol Schweiger 2012).

- Maps of the metro, bus, and Paris surroundings
- A map of the neighbourhood
- A wayfinding tool, built to be intuitive and easy to use. It is a sort of modern version of the PILI (plan indicateur lumineux d'itinéraires), or light-based itinerary indicator map), the famous push-button map tool introduced to the Paris metro in 1937
- Five 82-inch (208 cm) communication screens per platform, managed by the RATP's advertising arm Métrobus Publicité, for hosting ad campaigns and cultural content" (*16*).

Another sign technology discussed in the literature is electronic paper display (EPD). "EPD technology is an electronic sign capable of presenting text and images on a flexible surface that can be changed over time. EPD does not use a large amount of electricity. The technology has been in commercial use worldwide since 2005. It appears in electronic books, cell phones, electronic billboards and other general signage. EPDs are touted for their superior readability and extremely low power consumption, compared to traditional LED DMS or LCDs" (*17*). Figure 10 shows an example of an EPD.

> In 2006, *Hamburger Hochbahn AG*, a rail company operating in the City of Hamburg, Germany, installed 'mobile dynamic destination displays' of traveler information using EPD technology as part of a pilot project to assess the applicability of the technology as an alternative to traditional electronic signage. There is limited information regarding the results of the Hamburg experiment. As of mid-2009, no U.S. transit agencies could be identified as currently using the technology. However, during interviews with information technology staff at Tri-County Metropolitan Transportation District of Oregon, it was mentioned that they [were] currently researching the technology for use in their system. (*5*, pp. 39–40)

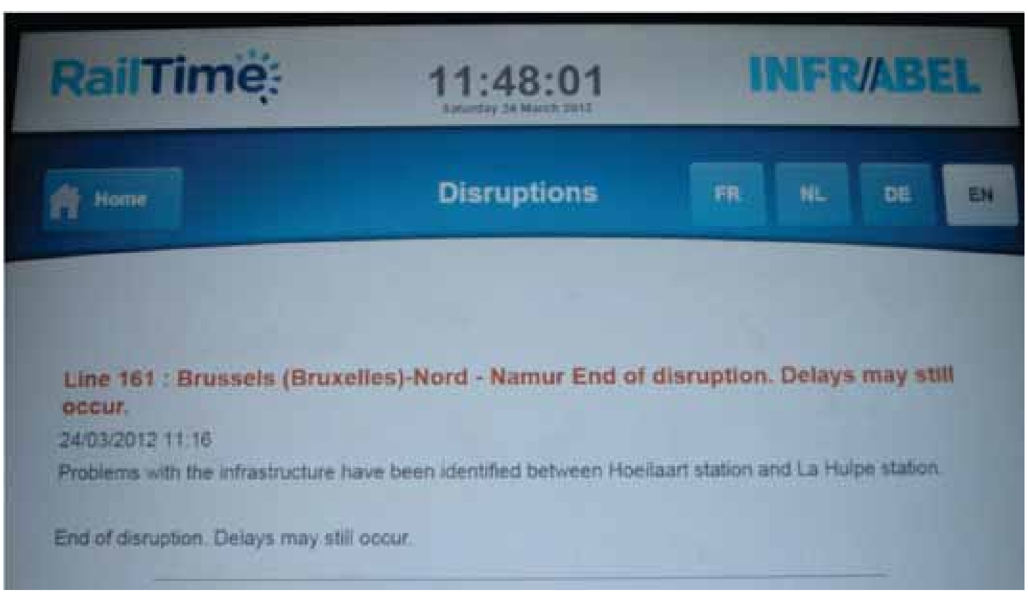

FIGURE 9 Disruptions displayed on touchscreen display inside Brussels–Central Rail Station (*Courtesy*: Carol Schweiger 2012).

FIGURE 10 Sample EPD (http://www.smh.com.au/news/breaking/electronic-paper-that-bends/2005/07/15/1120934404860.html).

Finally, several papers describe using electronic signage on highways to display both highway and transit travel times.

> Successful operation of the [changeable message sign] CMS system to disseminate highway driving time in the Bay Area led to the idea of displaying transit information along with freeway travel time. By displaying both travel times, by freeway and by train, travelers can make informed decisions about their commute. Caltrans District 4 is now comparing driving times with riding Caltrain Baby Bullet trains along the US-101 corridor. There are three signs designated to display highway travel time along with transit trip time—to San Francisco and San Jose—for Millbrae and Redwood City stations. These signs are located approximately half a mile from the freeway exit for the nearest Caltrain station. The signs display traveler information when the station-to-station train trip time is shorter than the highway travel time. This feature is designed to encourage motorists to use public transit during rush hours and reduce highway congestion. (*18*) (Figure 11)

FIGURE 11 Caltrans changeable message sign (*17*, p. 4).

Figure 12 shows the effect of the CMS. The results of the study are as follows:

- "The user satisfaction analysis indicated positive support for the transit-related CMSs and the general objective of sharing travel information with commuters.
- Drivers are likely to change to transit if transit can offer travel time savings over 15 minutes. Due to congestion in the Bay Area, taking transit can be faster during rush hours. In order to make transit more accessible, better information on the transit trip should be provided in addition to the travel time comparisons on the CMSs. Additional information can include real-time parking availability at stations and wayfinding kiosks at the destination station.
- A stronger mode switching effect can be expected in the afternoon peak hours due to greater travel time savings with transit.
- A network-wide deployment can have large effect on commuting behavior." (*19*)

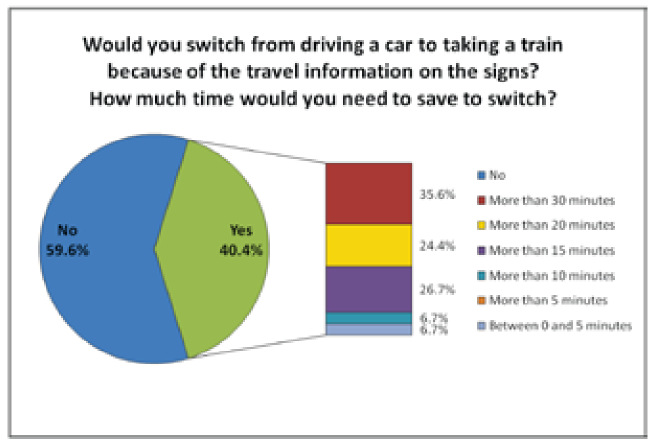

FIGURE 12 Willingness to take transit as a result of CMS Transit and Traffic Travel Time Information (*18*, p. 9).

Agencies represented on the oversight panel for this Synthesis expressed one primary concern regarding the application of this type of system: the ability to provide parking structures to support the number of individuals that might exit the freeway and take transit.

In the Boston area, the Massachusetts Department of Transportation (MassDOT) and the Massachusetts Bay Transportation Authority (MBTA) are sponsoring a DMS along Interstate 93 southbound that displays the time that the next commuter rail train departs from a commuter rail station located right off I-93:

> [A DMS] message board positioned just after the I-93 Concord Street Exit (Exit 39) will display the time of the next scheduled train departing from the Anderson-Woburn Regional Transportation Center on the Lowell Line during the morning commute. The message will be displayed [see Figure 13] until several minutes before the next departure to allow customers enough time to exit I-93 and drive safely to the rail station. (*20*)

FIGURE 13 I-93 southbound VMS displaying next train departure time (*19*).

Information Characteristics

Literature covering the characteristics of the information displayed on the signage is limited. In terms of message types and content, the following was offered by Katrin Dziekan:

> Real-time, at-stop displays must at their most basic level show the numbers or names of PT lines and routes, their directions, and departure times. These constitute specific stipulated user needs. Additional information that is valuable to the customers include: seat availability, arrival time for the next bus or train, and service attributes—such as low-step-up height. The more advanced the display is, the more and better become the potential planning options available to the users, especially during service disruptions. Digital countdown information is clear, and preferred by most (approximately 90%) of users. To differentiate between real-time and static timetable information, it could be wise to implement a standard that follows the natural feelings of the customers—with planned departure time always shown in digital time (for example 10:46), and real-time digital departure countdowns (for example 2 min). (*21*)

In London in 2009, TfL conducted an in-depth evaluation of Countdown signage in terms of what information should be displayed and the relative importance of each type of information (*22*). The key findings of the evaluation include the following:

> - The decision-making process and, therefore, information requirements are very different depending on scenario, ranging from normal service to severe disruption, and high frequency to low frequency services
> - The simplicity of information provision is key –don't over deliver. (*22*, p. 3)

In the normal service/high frequency situation, the basic information requirement is to provide reassurance; that is, bus will come in xx minutes.

Additional information that is desired:

> - Advance notice of buses not stopping
> - Planned engineering works/service cancellation information for all services from that bus stop
> - Delays/changes to service to onward journey and
> - Reassurance that more night buses to follow. (*22*, p. 3)

For normal, daily service, the results of this assessment are shown in Figures 14–17.

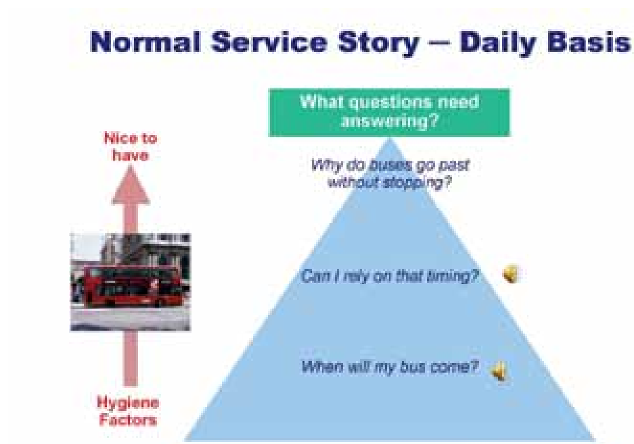

FIGURE 14 Countdown assessment for normal service (*21*, p. 20).

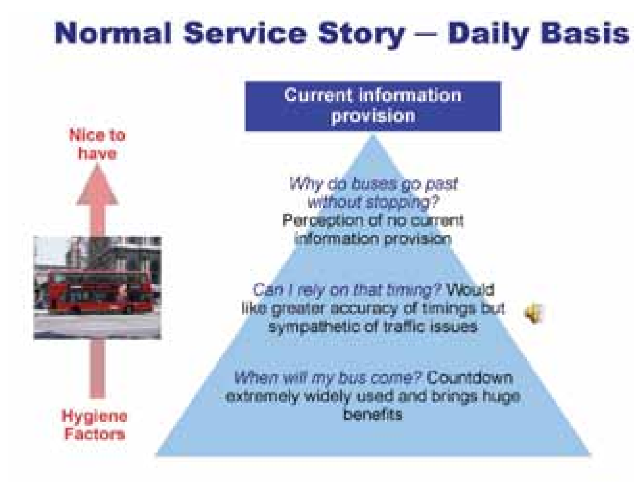

FIGURE 15 Countdown assessment for normal service (*21*, p. 21).

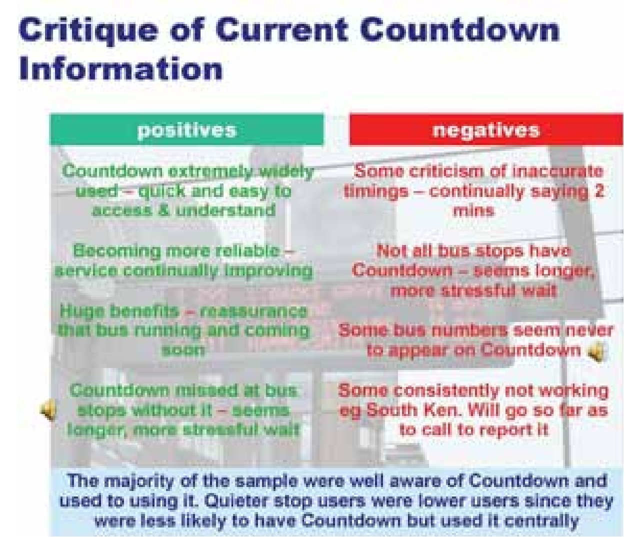

FIGURE 16 Countdown assessment for normal service (*21*, p. 22).

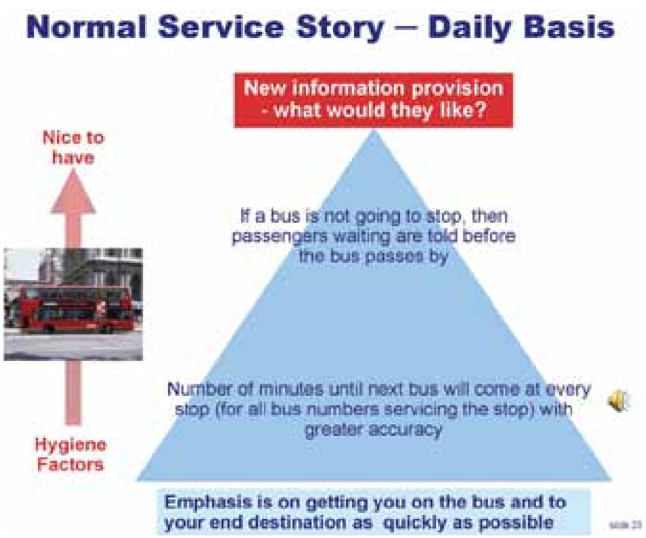

FIGURE 17 Countdown assessment for normal service (*21*, p. 23).

In the minor delays/medium frequency situation, the "information requirement is to provide reassurance and information to assist if plans need to change, i.e., bus will come in xx minutes but onward delay will be xx minutes. Additional information that is desired includes when an empty bus will arrive (not how crowded the bus is)" (*22*, p. 4).

In the severe delays/low frequency situation, the "information requirement is to provide information to replan the total journey, so delivery needs to be interactive to be able to provide tailored and specific advice. Additional information that is desired includes the reason for the disruption and the service status of other modes. At quieter stops, there is a greater need for reassurance as wait times can be much longer and a greater emphasis on alternative bus options in disruption scenarios" (*22*, p. 4).

The recommendations of the evaluation are as follows:

- The real challenge is providing appropriate information at the right time, through the most accessible channel
- Any information provision needs to be simple, clear and usable
- There is a potential danger of over-delivering which would not delight but just confuse
- Simplicity would delight especially in the most simplistic of decision-making scenarios
- Over-delivery would annoy –'who cares that the driver didn't turn up for work –where is my bus?'
- There is no difference in information provision at quieter stops since the decision-making process is identical, only greater reassurance is required. (*22*, p. 44)

As of July 9, 2012, 2,496 Countdown signs have been installed as part of the iBus system (*23*).

U.K. Network Rail has an OIS Process Guide that shows the content of many different types of passenger information displayed on electronic signs (*3*).

> The Operational Information System (OIS) is a Network Rail system which is deployed nationally—large electronic display screens are installed at key stations, control centres and some Network Rail corporate offices. The primary objective is to increase passenger awareness of changes to train services either in advance, or in real time due to service disruption.
>
> The types of information displayed on the screens include:
>
> i. Standard passenger advice (e.g., unattended items and train doors close prior to departure time, CCTV is fitted / Help Points are available, where fitted)
> ii. Current service information and apology messages
> iii. General station information
> iv. Details of planned engineering works
> v. Rainbow boards (see Figure 18 for an example) (network status' for TfL and [Train Operating Companies] TOCs, where agreed)
> vi. Train service performance figures at stations agreed between Network Rail and TOCs
> vii. Other approved content. (*3*)

FIGURE 18 "Rainbow Board" example (*Courtesy*: TfL, http://www.tfl.gov.uk/).

Various types of information are provided in National Rail stations as follows (*3*, p. 4):

- National Rail Enquiries provides planned engineering works information;
- TfL provides London Underground service information at National Rail stations that are equipped with OIS and are within a 35-minute journey time from a central London station. Also, all London airport railway stations that are equipped with OIS display London Underground service information from TfL.

Network Rail identifies "Core Messages," which—

> must contain three distinct pieces of information:
>
> **The Problem** What has occurred
>
> **The Impact** What impact will this have on passenger journeys (including any available time estimates)
>
> **The Advice** What passengers should do
>
> The over-riding principle of a Core Message must be that ***it is written as if you were talking directly to the customer*** (write the message in plain English so that it is easily understood, without using railway terminology or jargon). It must provide information that is of relevance to a range of customers with a wide variety of needs. (*3*, p. 12)

"Further, OIS has defined message priority levels within the system so that messages of certain priority take preference over lower priority messages (in their frequency and also removal of certain lower priority messages). These priority levels are defined" (*3*, p. 21) in Table 1.

The U.K. survey conducted by RTIG (*6*, pp. 50–53),

> investigated what channels are being used for disseminating disruption information, approximately how long it takes to distribute information about unplanned disruptions, and the capability of [local authorities] LAs to disseminate information out of working hours. (*6*, p. 50) During times of disruption, LAs either put a standard holding message on their on-street signs, or give out real time information about the disruption on their signs. Only a few—8 out of 53—actually turn their signs off. Disruption information is provided through a number of channels and most LAs provide information through more than one. 43 LAs across the UK reported using on-street signs to distribute information about unplanned disruptions. 6 LAs reported using only on-street signs for information provision, while 37 use them alongside websites. Most LAs are able to provide information in 30 minutes or less while a few are taking more than 3 hours. Slightly less than half of LAs (*23*)

TABLE 1
NETWORK RAIL MESSAGE PRIORITY

Priority Level	Frequency
Base Core Content (not available to OIS operators)	Same frequency as per Low priority messages
Standard passenger advice animations (e.g., unattended items and train doors close prior to departure time)	Will be removed by a Medium, High, or Emergency priority message
Approved content requests	
Engineering Work XML (not available to OIS operators)	Same frequency as per Low priority messages
Planned engineering works XML	Content will be removed by High or Emergency priority message
Rainbow XML (not available to OIS Operators)	Same frequency as per Low priority messages
Rainbow Board XML feeds	Content will be removed only by an Emergency priority message
RTPPM information (where agreed)	
Low	General passenger advice messages
Restoration of normal services following disruption messages	Content will be removed by High or Emergency priority message
Apology messages	
Messages advising of additional trains on some routes	
Medium	Displays at twice the frequency as Low and equal frequency to other Medium messages
Non-CSL2 service disruption (line problems with delays above 10 min, except when CSL2 has been declared and active), planned industrial action, emergency engineering works, safety messages relating to weather warnings, irregular congestion due to sporting event/concert, etc.	
Contingency timetable introduced for entire network and trains running well against plan	
High	Displays at twice the frequency as Medium and equal frequency to other High messages
CSL2 declared and active	
Contingency timetable introduced for entire network and trains disrupted	
Do-not-travel messages	
Emergency	Removes all other content.
Emergency messages only (e.g., please evacuate the station immediately)	

> who responded were able to provide disruption information out of hours, while 32 could not. (*6*, p. 51)

INFORMATION ACCESSIBILITY

In terms of accessibility, the literature suggests that there is a growing trend toward providing both audio and visual announcements.

> Currently, there are no U.S. laws that explicitly address the accessibility of this type of information, which is disseminated via media such as dynamic message signs (DMS), mobile telephones and interactive voice response (IVR) systems. The key issue regarding the accessibility of real-time information is providing the information in alternate formats so that persons with disabilities can access it in an equivalent way to persons without disabilities. For information provided visually, the audio equivalent of that information should be provided. And vice versa, if audio information is provided, the information should be provided visually. (*24*, pp. 1–2)
>
> In fact, there is no specific portion of U.S. law that absolutely states that visual information must be provided in audio format and vice versa. However, several portions of the Americans with Disabilities Act (ADA) of 1990, the ADA Accessibility Guidelines (ADAAG), and rules and regulations issued by some U.S. states (e.g., Massachusetts Architectural Access Board (MAAB) Rules and Regulations) state in various ways that alternate formats must be provided. (*24*, p. 2)
>
> Specifically, this includes the following citations:
>
> - ADA:
>   - 49 Code of Federal Regulations (CFR) Part 37; §37.167 Other Service Requirements (f)
>   - 49 CFR Part 37; §37.5 Nondiscrimination (f)
>   - 28 CFR Part 36; §36.302 Modifications in policies, practices, or procedures (b) Specialties (1)
>   - 28 CFR Part 36; §36.303 Auxiliary aids and services
> - ADAAG:
>   - Sections 218 and 810 of the ADAAG
>   - 4.30 Signage
>   - 10. Transportation Facilities
> - Electronic and Information Technology Standards detailed in Section 508 of the Rehabilitation Act [4]. While Section 508 requirements are technically only applicable to federal agencies and their contractors, these standards have been widely and proactively accepted by public and private transportation agencies. (*24*, p. 2)
>
> At the State level, there may be requirements that govern the need to provide alternate formats, such as Section 18 of the Massachusetts Architectural Access Board regulations (521 CMR). In this case, Section 18.11—Announcements in Seating and Platform Areas states that 'Visual systems for providing announcements to deaf and hard of hearing customers shall be provided wherever there are auditory systems for providing announcements.' In addition to federal and state regulations, standards and guidelines, commitments made at the local level by a public transport agency regarding information and communications accessibility should be considered.
>
> It is important to note that U.S. federal and state regulations and standards are somewhat general in the area of information and communications accessibility. In some sense, technology advancements are ahead of the regulatory process. In addition to meeting federal and state requirements, real-time public transportation information systems should be fully usable by all riders, including riders with disabilities. (*24*, p. 2)

In the United States, several transit agencies have deployed electronic signage that provides audio in a variety of ways:

> There are multiple approaches to providing audio information. Announcements of DMS displays could be made at acceptable intervals (e.g., every three minutes). Second, a push-button that is pressed and provides an audio announcement of what is displayed on the DMS is another possible alternative. Persons who are blind or visually-impaired would have to be directed to the location of this type of push-button, often done by audio alarm. Third, providing detailed information via telephone is another possible alternative. Finally, an infrared device (e.g., Talking Signs®) that provides the audio equivalent of what is displayed on a DMS could be utilized. This alternative may require that the public transport authority provide visually-impaired riders with the infrared device. Other alternatives, such as a stationary device (e.g., a telephone at a stop/station that is directly connected to the customer information department) that provides direct access to an interactive voice response (IVR) system, should be explored. (*24*, p. 4)
>
> Remote Infrared Audible Signage (RIAS) or 'talking signs' provide a signage system for blind, visually impaired, or cognitively or developmentally disabled transit users. RIAS consists of infrared transmitters that continuously broadcast directional information and spoken messages to wireless receivers carried by a user. The handheld devices relay station navigation or traveler information to a user via audio messages. (*5*, p. 38)
>
> RIAS has been deployed in a number of U.S. cities, at select transportation centers and buildings, as well as internationally in Canada, Italy, Japan, Norway, Scotland and Turkey. RIAS has not yet become a widespread proven system. However, some of the U.S. transit agencies do currently operate RIAS technology in selected transit stations. These agencies include the Bay Area Rapid Transit (Powell Street Station and Fremont Station), San Francisco Municipal Railroad (selected stops), and Capital Area Transit Authority in Lansing, Michigan (on all buses). These agencies operate RIAS in support of a single mode of transportation (bus or rail). (*5*, pp. 38–39)
>
> A demonstration of RIAS in the Puget Sound area is the first multimodal application that seeks to provide a seamless connection of signage among different modes. Potential challenges associated with the widespread deployment of RIAS systems include geographic scope and service population, which both impact the associated costs and benefits of system implementation. The effectiveness of a RIAS network is dependent on its comprehensive nature and on its ability to communicate seamlessly inside and outside of transit systems. RIAS networks are optimally provided in combination with other common public signage such as crosswalk and street signals and other directional aids. In addition, the potential size of the visually impaired or cognitively disabled community benefiting from a RIAS network must be commensurate with the associated system deployment costs. (*5*, p. 39)

In the United Kingdom, RTIG reports that the use of audio at stops that have an electronic sign has grown over the past several years, but has not grown much over the past year. Figure 19 shows various methods that are used to provide audio at stops in the United Kingdom to augment electronic displays (*6*, p. 25).

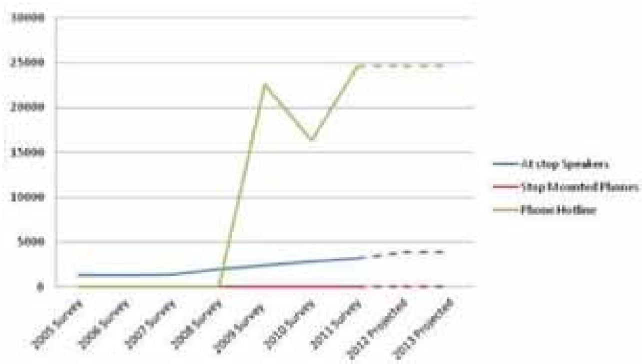

FIGURE 19 Audio provision at stops 2005–2013 (*6*, p. 26).

In March 2012, RTIG published guidance regarding meeting the needs of disabled passengers for real-time information (*25*). This document includes specific recommendations related to electronic signage in the following categories:

- Font and format—Recommendations are provided to ensure clarity and legibility specifically for users with visual and cognitive impairments;
- Refreshed text—Recommendations are made regarding scrolling or refreshing text where text is too long to fit on a single line on a screen. The recommendations reflect a "tradeoff between the informativeness of the message and its length: a longer message may give more information, but it may be more complex, require scrolling or take more time" (*25*, p. 7).
- Scrolling text—Recommendations are made regarding increasing legibility when scrolling.
- Sign finish, contrast and borders—Recommendations regarding these items are made because they "can affect users' ability to discriminate the information on the sign" (*25*, p. 9). Further, there are guidelines that state that:
  - Signs need to be made of materials which do not cause undue reflection or glare
  - The message should contrast with its background to ensure clarity and legibility
  - It is important that the borders contrast with the colors and materials behind the sign so that the sign is immediately visible.
- Sign positioning, lighting and environment on buses—Recommendations are provided to ensure that signs in buses are positioned so that a passenger is not required to search to find them. In general, recommendations include the following:
  - "Signs should face the largest number of passengers possible
  - Ideally more than one sign should be provided
  - Signs need to be well lit, but should not be positioned such that they cause glare
  - Uniformity of illumination and contrast is important to those with visual impairments" (*25*, p. 10).
- Sign positioning and environment at stops and shelters—Recommendations in this area include signs having as long sight lines as possible and the potential need to be angled. Further, recommendations include considering providing signs at two heights for standing and wheelchair users. Finally, recommendations discuss that signs should be well lit, but protected from direct sunlight or artificial light to avoid glare (*25*, p. 11).

This report also provides guidelines for audible assistance systems in the following categories:

- Provision of audible information, messages and announcements—recommendations are made in this covering the following (*25*, p. 19):
  - Visual information should be presented in audible form where possible
  - All audio information should be provided with enough time for passengers to act on the information and where possible should be repeated
  - Complete one message before starting another, if possible
  - Ensuring voice intelligibility so that messages are understood.
- Audio systems—Recommendations cover consideration of background noise and having the audio be loud enough to be heard above it, but not so loud as to cause a nuisance.
- Hearing enhancement—Recommendations cover systems such as induction loops, infrared or radio transmission to help make audio announcements more accessible to hard of hearing passengers by mitigating the effects of distance from the sounds source, ambient noise and reverberation.
- Triggering audio assistance with keyfobs (small handheld device which triggers an audio announcement by means of short range radio waves at a distance of between 5 and 8 meters).
- Triggering audio assistance with smartcards.
- Synthesized speech—Recommendations cover various technical approaches to the speech synthesis.

In the La Défense subway station in Paris, a touchscreen monitor, which is accessible to persons with disabilities, provides information on public transport, station services, shops, and the station exterior by means of a 40-in. interface (*15*, p. 111). The touchscreen is activated by waving a hand and then provides "four functions: search for destination by name, search for destination by theme, access latest information on destinations and surfing the whole map. Both the screen and its cradle are adapted for use by wheelchair users and the visually impaired. 'The ergonomics of the cradle mean wheelchair users can access the screen face on, by sliding their wheelchair underneath. The blind can also locate it using their cane, plus the keys are visually enhanced. The programme itself gives details on accessibility and lifts in the station and its surroundings" (*15*, p. 112).

ACCURACY AND RELIABILITY

In terms of accuracy and reliability, Dziekan (*21*) stated that "real-time information displays must work reliably, otherwise users lose confidence in the system very quickly, as system performance can be checked on the spot. Once that happens, it becomes much harder to satisfy the user, and overcome prior negative experience" (*21*, p. 19).

In London, the iBus system, which replaced the original Countdown system, includes Real Time Passenger Information (RTPI) at bus stops—"approximately 2000 signs installed at bus stops across London providing estimated times of arrival for vehicles" (*26*, p. 2). "More reliable equipment and an improved prediction algorithm are expected to produce fewer non-predicted buses that fail to show a prediction, greater accuracy of arrival times, and for the first time pre-trip predictions i.e. predictions displayed for a bus whilst the vehicle is on a preceding trip" (*26*, p. 3).

MONITORING

Several papers reported monitoring the accuracy and reliability of the information presented on electronic signage. At the Chattanooga Area Regional Transportation Authority (CARTA), the DMS "were tested for operability, accuracy and reliability during the test period. Additionally, the DMS system was evaluated by the CARTA Technology Director to ensure proper integration with CARTA's overall ITS system (*27*).

In Busan, Korea, "The information and the accuracy of the bus information system were found very satisfactory. Satisfaction with the bus headway improved compared with the before-study result by about 9%. The accuracy of bus headway or arrival information and the satisfaction with bus information booths improved, leading to higher reliability of bus arrival information" (*28*).

In Thessaloniki, Greece, "The analysis performed on the data collected from the survey of both regular and circumstantial PT users in the city of Thessaloniki shows that the existing RTPI system is generally evaluated positively. Satisfaction levels are quite high, more than 80% for both the content and the reliability of the information given" (*11*, p. 254).

STANDARDS

Several papers discussed the current standards for the implementation of electronic signage. One underlying standard that is being deployed extensively in Europe and now in the United States is SIRI. "SIRI specifies a European interface standard for exchanging information about the planned, current or projected performance of real-time public transport operations between different computer systems" (*29*). "SIRI is intended to be used to exchange information between servers containing real-time public transport vehicle or journey time data. These include the control centres of transport operators and information systems that utilise real-time vehicle information to operate the system, and the downstream systems that deliver travel information to the public over stop and onboard displays, mobile devices, etc. SIRI uses eXtensible Markup Language (XML) to define its messages" (*29*, p. 3) "SIRI uses open standards and is platform independent in that it is free to use and can be deployed onto any general computer operating system that supports XML" (*30*).

Two of the services available in SIRI are the "Stop Timetable and Stop Monitoring services. The Stop Timetable (ST) and Stop Monitoring services (SM) provide stop-centric information about current and forthcoming vehicle arrivals and departures at a nominated stop or Monitoring Point, typically for departures within the next 20–60 minutes for display to the public. The SM service is suited in particular for providing departure boards on all forms of device" (*29*, p. 7). Figure 20 shows how this service works with DMS.

SIRI provides the following eight services:

- Production Timetable Service
- Estimated Timetable Service
- Stop Timetable Service
- Stop Monitoring Service
- Vehicle Monitoring Service
- Connection Timetable Service
- Connection Monitoring Service
- General Messaging Service

TransXChange (TxC) is another standard used in the implementation of DMS. "TxC is an XML based UK standard for exchanging PT data. It is used by the Traffic Area Networks (TAN) and the Vehicle and Operators Services Agency (VOSA) to register bus schedules electronically. It is also used to exchange such PT information with other computing systems such as journey planners and RTI systems" (*30*, p. 15). TxC has five services: Creating Schedules, Submitting Schedules, Publishing Schedules, Exchanging Schedules and Importing Schedules (*29*, p. 16). Although the word "schedule" is used in these service titles, real-time information is included in these services.

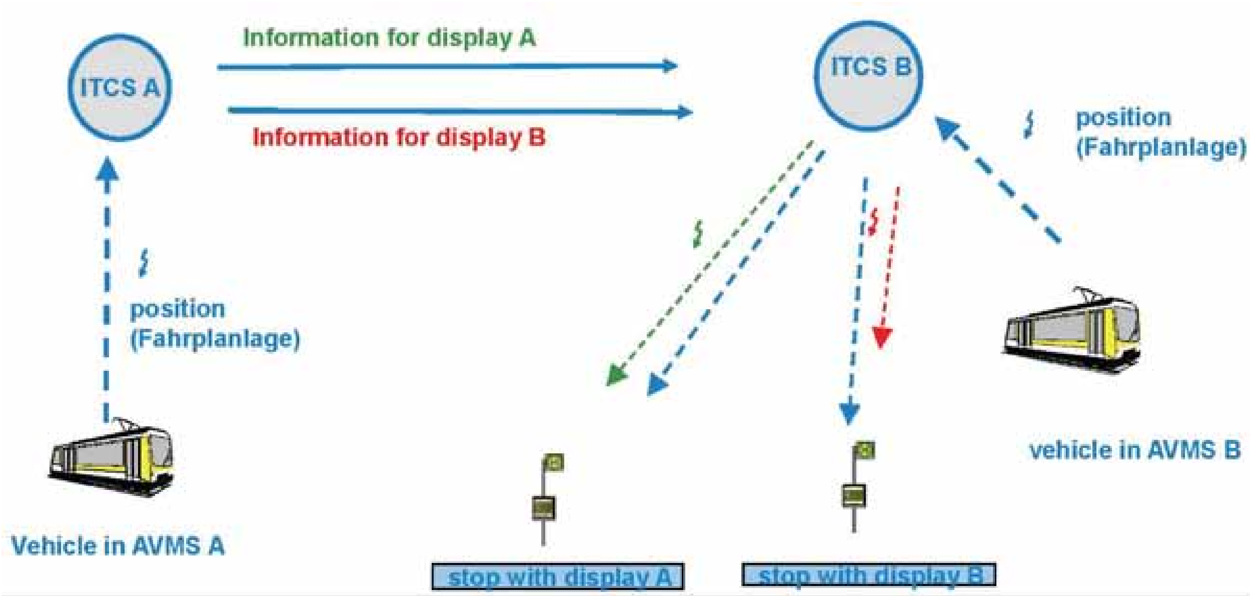

FIGURE 20 SIRI stop timetable (ST) and stop monitoring services (*28*, p. 7). AVMS = automatic vehicle monitoring system; ITCS = Intermodal Transport Control System.

As mentioned earlier, the display system at Southampton Airport uses

> standard modern Internet processes to transfer the information from the data providers to the travel display system. Essentially, the system acts as a real-time travel information nexus, automatically and continuously gathering data from remote data sources of travel information using standard communications protocols such as XML (eXtensible Markup Language) and Internet protocols such as SOAP (Simple Object Access Protocol). This data is then automatically formatted into a defined standard XML format by our adapter software written in Java. (*8*, p. 3)

In Johannesburg, South Africa, the BRT "DMS signs support the [National Transportation Communications for ITS Protocol] NTCIP protocol which provides a standard communications interface" (*10*, p. 6). NTCIP "is a family of standards that provides both the rules for communicating (called protocols) and the vocabulary (called objects) necessary to allow electronic traffic control equipment from different manufacturers to operate with each other as a system" (*31*).

A new standard that is being used is to provide real-time information to various applications is called the General Transit Feed Specification (GTFS)-realtime:

> GTFS-realtime is a feed specification that allows public transportation agencies to provide realtime updates about their fleet to application developers. It is an extension to GTFS (General Transit Feed Specification), an open data format for public transportation schedules and associated geographic information. GTFS-realtime was designed around ease of implementation, good GTFS interoperability and a focus on passenger information. (*32*)

> The Virginia Department of Rail and Public Transportation (DRPT) has led an effort to create a technology community for transit operators statewide and has commissioned a standards working group. DRPT is interested in making real-time and historical data available to the public and to 3rd party developers in order to improve passenger information, government transparency and multimodal transportation options in the state and is using the working group to ensure statewide coordination. (*33*)

The Transit Real-Time Traveler Information Standards Working Group examined several relevant standards, including "GTFS, TCIP—transit communications interface profiles, SAE J-2354—defines multimodal traveler itinerary requests and responses, and SIRI" (*33*, p. 1).

REQUIRED RESOURCES

Several pieces of literature discuss the resources required to implement, operate, and maintain electronic signage. Ferris et al. (*34*) state that

> it is likely to be prohibitively expensive to provide and maintain such displays at (for example) every bus stop in a region. With the increased availability of powerful mobile devices and the public availability of transit schedule data in machine readable formats, there have been a significant number of tools developed to improve the usability of public transit, especially mobile tools. One motivation is that, as noted above, it is unlikely that real-time transit information will be available on a public display at every stop. Another is that personal mobile devices can also support additional, personalized functionality, such as customized alerts.

Further,

> the investment in website and phone-based real time transit information can also save an agency substantially in deployment costs. As an example, Portland deployed their Transit Tracker program in 2001 with information displays at stops, a webpage and more recently a phone system. The transit tracker signs at light rail stations and 13 bus stops in Portland cost $950,000 including message signs and conduit. The cost for computer servers and web page development was much cheaper at $125,000. Given the widespread availability of cell phones and web access, providing real time transit information via a service such as OneBusAway [http://www.onebusaway.org/] could yield a substantial savings for an agency over constructing real-time arrival display signs. (*35*)

As mentioned earlier, the price of the two-screen displays deployed in some locations in Belgium (€17,000) caused the National Railway Company of Belgium (SNCB) to implement a digital advertising network including LCD screens with portrait orientation and panoramic screens that display both advertising and traveler information (*15*, pp. 113–114).

In Thessaloniki, Greece, "the overall acceptance level is high and it seems that the implemented system is both economically feasible and financially viable. In economic terms annual benefits are twice the investment cost of the system. The main financial benefits come from the reduction of the PT operations costs as a result of the AVL system" (*11*, p. 254).

DECISION PROCESSES

A variety of literature describes the processes that agencies use to determine if electronic signage should be deployed and where it could be located. First, literature describing the benefits of electronic signage was reviewed because it was found that the identification of benefits often contributes to the decision about whether signage will be deployed. Several papers discussed how real-time information often reduces passengers' perceived waiting times at stops and stations: "Although stop signage with next-arrival information does not directly reduce wait times, since passengers have to be at the stop to know this information, it reduces anxiety and may provide a perceived benefit of less safety and security risk. By knowing next-bus arrival information, passengers may be able to make better use of their time or seek alternate modes of transportation (e.g., if the wait time is too long)" (*36*).

The effect of providing real-time information displays at transit stops has been reported in several locations around the world, as follows (*37*):

- In Stockholm, a study showed that passengers without real-time information displays at their stop overestimated their wait time by 24% to 30%, compared with those who had real-time information at their stop, who overestimated their wait time by 9% to 13%.
- "In London, the provision of real-time information at stops was found to reduce perceived wait time by 26 percent" (*37*).
- In the Netherlands, the introduction of passenger information displays on a tram line in The Hague resulted in a reduction of perceived wait time by 20%.

Generally, "it is well known that people like at-stop real-time information and have very positive attitudes towards it" (*38*). Dziekan and Kottenhoff also described the most significant benefits of electronic signage at stops: increased feeling of security, reduced uncertainty, increased ease-of-use, increased willingness-to-pay, adjusted travel behavior and other adjusting strategies (such as letting a crowded bus go by if the display showed that another would be arriving shortly, and adjusting walking speeds according to the information received by at-stop real-time information displays), mode choice, higher customer satisfaction, and better image (*38*, pp. 492–495).

In a 2011 survey of New York Metropolitan Transportation Authority customers,

> Countdown clocks are having a positive impact on the overall customer experience. All 54 subway service and station attributes were rated higher by those with countdown clocks in their station than those without a countdown clock in station. This includes:
>
> - Customer Information:
>   - Knowing how long until next train arrives
>   - Clarity of announcements on station platforms
>   - Information in station about unscheduled delays
> - Service Performance:
>   - Predictability of subway travel time
>   - Service frequency
>   - Service reliability
> - Personal Security: Personal security in station after 8 p.m. (*39*, p. 6)

Further, satisfaction with countdown clocks in 2011 was 59% very satisfied and 37% satisfied for a total of 96%. "Satisfaction improved statistically on information about delays, reflecting improved planned service change posters and LEDs on countdown clocks" (*39*, p. 12).

Although not specific to electronic signage, the research conducted by Tang and Thakuriah (*40*) implies the following:

> - Real-time information systems provision should be considered as one way to improve transit ridership. The psychological benefits brought about by such systems are one of the reasons leading to the ridership gain.
> - Real-time information systems have the potential to serve as a good intervention to change the travel habit of current transit non-users and increase their transit use, thus such systems have the potential be used as a tool to increase transit mode share.
> - As past experience with real-time transit information systems has positive effect on commuter's attitudes and intentions to increase transit use if such a system is

> provided, for transit systems that are planning to deploy such systems, the facilitating programs to familiarize commuters with real-time transit information systems may help to increase transit ridership. (*40*)

SELECTION CRITERIA

In terms of selecting electronic signage over other dissemination media, the literature describes various selection processes. In Caulfield and O'Mahony (*37*), "respondents were asked to choose between three options of accessing real-time public transit stop information: SMS, a passenger information display, or a call center (*37*, p. 5). The results show respondents derive the greatest benefit from real-time public transit stop information displays. This result was as one would expect, as this is one of the most effective methods of relaying real-time public transit stop information" (*37*, p. 18).

SIGNAGE PLACEMENT

In terms of where signage should be located, the literature describing the status of electronic signage in the United Kingdom identifies the locations as shown in Table 2 (*6*, p. 23). "By the end of 2011, the majority of [real time information] RTI displays were installed in shelters (64%), or flag [pole-mounted] installations (26%). Overall this marks a shift towards flag installations and away from shelters compared with 2010. Signage in all locations has risen since last year, though the increase in flag installations is particularly marked, rising from 1,972 flag installations in 2010 to 2,872 in 2011. This rise of 900 signs is largely accounted for by apparent growth of 740 in the East Midlands. However, this is the result of a new return which we did not have last year" (*6*, p. 24).

TABLE 2
SIGNAGE LOCATION IN GREAT BRITAIN*

Location Position within GB end-2011	No. RTI Displays	RTPI Physical Display Location				
		Flag installation	Shelter	Transport Hub	Private building	Other
Metropolitan	4,453	487	2,453	594	41	2,501
Non-Metropolitan	3,532	2,385	2,527	306	95	5,193
London	2,000	-	2,000	-	-	-
TOTAL	9,985	2,872	6,980	900	136	7,694

*"Note that there are more signs accounted for in physical locations than the total number of physical signs (for instance the sum of total shelter, total flag, total hub etc displays is 10,888, which is 904 more than are accounted for by the LEDs and LCDs). We have not included "other" in this calculation since a number of people included virtual signage in this category" (*6*, p. 24).

In Plymouth, United Kingdom (*41*), the Public Transport Information Strategy includes the continued "rollout of RTPI displays in bus shelters throughout the City but will give priority to stops on the selected Quality Bus Corridors" (*41*, p. 16). Quality Bus Corridors are defined as important strategic routes that are improved to increase bus use. Improvements are introduced to make buses more reliable and passenger waiting facilities more efficient and comfortable (*42*).

CHAPTER THREE

ELEMENTS OF DEPLOYING ELECTRONIC SIGNAGE

The Synthesis survey covered several key characteristics of the underlying technology required to generate the information that is displayed on electronic signs, the sign technology, and the displayed information. (Table 3 and Appendix B list of the 37 responding agencies.) Before examining these characteristics, the overall annual ridership and modes operated by each respondent were noted. Annual ridership ranged from 1 million (a respondent with fixed-route bus service) to 3.6 billion (TfL). Total annual ridership for each agency is shown in Appendix C.

TABLE 3
RESPONDING AGENCIES

Agency Name	City	State/Province/ Country
Alameda–Contra Costa (AC) Transit	Oakland	CA
Agence métropolitaine de transport (AMT)	Montreal	Quebec
Bay Area Rapid Transit (BART)	Oakland	CA
Blacksburg Transit	Blacksburg	VA
Brampton Transit	Brampton	Ontario
Capital Metropolitan Transportation Authority (CMTA)	Austin	TX
Central Florida Regional Transportation Authority (LYNX)	Orlando	FL
Central New York Regional Transportation Authority	Syracuse	NY
Centre Area Transportation Authority (CATA)	State College	PA
Charlotte Area Transit System	Charlotte	NC
Chattanooga Area Regional Transportation Authority (CARTA)	Chattanooga	TN
Chicago Transit Authority (CTA)	Chicago	IL
City of San Luis Obispo Transit/SLO Transit	San Luis Obispo	CA
City of Wichita, KS	Wichita	KS
GO Transit	Toronto	Ontario
Hillsborough Area Regional Transit Authority (HART)	Tampa	FL
Ixxi —RATP Group	Paris	France
Kansas City Area Transportation Authority (KCATA)	Kansas City	MO
King County Metro	Seattle	WA
Madison Metro Transit	Madison	WI
Massachusetts Bay Transportation Authority (MBTA)	Boston	MA
Metropolitan Transportation Authority (MTA), New York City Transit (NYCT)	New York	NY
Mobility Lab	Arlington	VA
Monterey–Salinas Transit (MST)	Monterey	CA
Network Rail Infrastructure Ltd.		UK
NJ Transit	Newark	NJ
Pinellas Suncoast Transit Authority (PSTA)	St. Petersburg	FL
rabbittransit	York	PA
Region of Waterloo (Grand River Transit)	Waterloo	Ontario
Regional Transportation Commission of Washoe County (RTC)	Reno	NV
Société de transport de Laval	Laval	Quebec
South Yorkshire Passenger Transport Executive	South Yorkshire	UK
Transport For London (TfL)	London	UK
Tri-County Metropolitan Transportation District of Oregon (TriMet)	Portland	OR
Urban Public Transport Organisation of Thessaloniki	Athens	Greece
Utah Transit Authority (UTA)	Salt Lake City	UT
Votran	South Daytona	FL

REQUIRED UNDERLYING TECHNOLOGY, AND SIGNAGE TECHNOLOGY AND CHARACTERISTICS

Table 4 presents the survey results that indicate the types of underlying technology being used. These results support the concept that CAD/AVL is the primary underlying technology required to determine the real-time information displayed on electronic signage for bus systems. In terms of the communication technology used to send information to an electronic sign or send "health" information from the sign, the most prevalent technology reported by survey respondents is hard-wired (e.g., Ethernet), followed by cellular radio network. For the real-time prediction software, more than half of the respondents have software as part of their vehicle location system.

TABLE 4
UNDERLYING TECHNOLOGY

Underlying Technology	Response Percent*
Vehicle tracking: Computer-aided dispatch (CAD)/ automatic vehicle location (AVL)	83.3
Vehicle tracking: Global positioning system (GPS)	80.6
Vehicle tracking: Rail signal system	25.0
Sign communication: Hard-wired communication (e.g., Ethernet)	61.1
Sign communication: Cellular radio network	52.8
Sign communication: Wireless area network (e.g., wireless Ethernet)	27.8
Sign communication: Agency radio network	25.0
Real-time prediction software: Purchased as part of a CAD/AVL or related system	52.8
Real-time prediction software: Developed in-house	27.8
Real-time prediction software: Licensed (software-as-a-service)	16.7
Real-time prediction software: Purchased independently	13.9
Real-time prediction software: Open source	8.3

*Not all survey respondents answered every survey question, so the response percent represents the number of respondents that answered this particular question out of all respondents that answered this question.

The responding agencies use two primary types of signage, as shown in Figure 21. LED signs are the most prevalent, followed by LCD signs (also known as full-screen displays). Table 5 shows the number of LED and LCD signs that have been deployed by the responding agencies.

As shown in Table 6, indoor LED signs are mostly located inside transit stations; outdoor LED signs are at bus/BRT stops with shelters (most prevalent), outside transit stations and at transfer locations (next most prevalent) and at the end of a line/route terminal (next most prevalent); indoor LCD signs are mostly in transit stations; and outdoor LCD signs are outside transit stations (most prevalent) and at transfer points (next most prevalent).

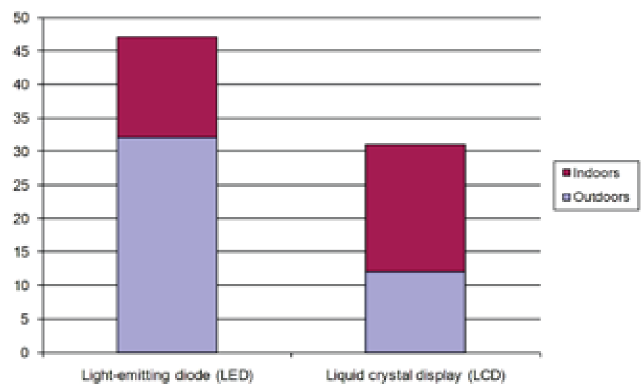

FIGURE 21 Number of responding agencies with LED and LCD signage.

TABLE 5
NUMBER OF SIGNS DEPLOYED BY RESPONDING AGENCIES

Indoor LED Signs	Outdoor LED Signs	Indoor LCD Signs	Outdoor LCD Signs
3,160	5,219	512	829

There is a wide variation in the dimensions of each type of electronic sign. Figures 22 through 39 show this wide variation.

TABLE 6
SIGN LOCATIONS BY PERCENTAGE OF RESPONDING AGENCIES

Other Electronic Sign Locations	Inside transit station (e.g., on subway platform, at faregates)	Outside transit station	Inside non-transit location	Outside non-transit location	At bus/BRT stops with shelter	At bus/BRT stops without shelter	At end of line/route terminal	At transfer stop
Indoor LED	27.8	2.8	8.3	0.0	5.6	0.0	8.3	5.6
Outdoor LED	16.7	36.1	0.0	8.3	58.3	19.4	33.3	36.1
Indoor LCD	36.1	2.8	19.4	2.8	2.8	0.0	8.3	8.3
Outdoor LCD	11.1	13.9	0.0	0.0	8.3	2.8	2.8	11.1
Indoor Other	11.1	0.0	2.8	0.0	0.0	0.0	0.0	0.0
Outdoor Other	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

FIGURE 22 Monterey Salinas Transit DMS (*Courtesy*: Carol Schweiger 2009).

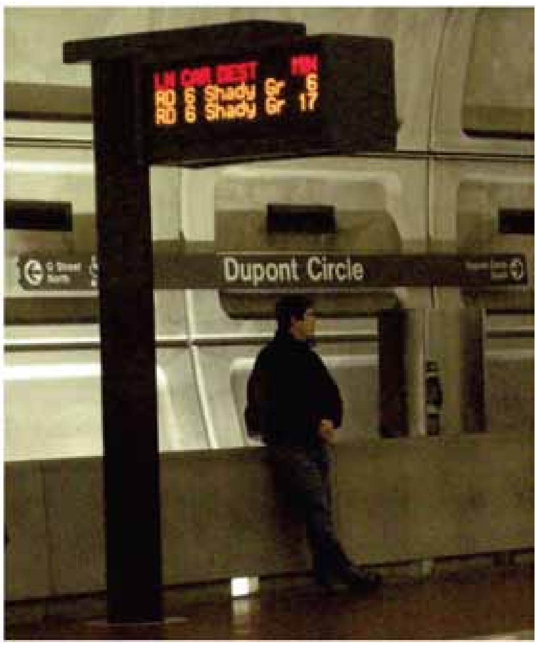

FIGURE 23 WMATA DMS in Dupont Circle Metrorail Station (*Courtesy*: Carol Schweiger 2007). \

FIGURE 24 Mesa (Arizona) BRT station DMS (*Courtesy*: TranSystems 2011).

FIGURE 25 KCATA MAX (BRT service) DMS (*Courtesy*: TranSystems 2005).

FIGURE 26 Helsinki tram station DMS (*Courtesy*: Carol Schweiger 2009).

FIGURE 27 DMS in Milan, Italy (*Courtesy*: Carol Schweiger 2008).

FIGURE 28 Electronic sign in Seoul subway station (*Courtesy*: Carol Schweiger 2010).

FIGURE 29 Bus stop electronic sign in Brussels, Belgium (*Courtesy*: Carol Schweiger 2012).

FIGURE 30 Denver Regional Transportation District (RTD) sign at Market Street Station (*Courtesy*: Carol Schweiger 2012).

FIGURE 31 Denver Regional Transportation District (RTD) sign at Market Street Station (*Courtesy*: Carol Schweiger 2012).

FIGURE 32 AMT LED sign (*Courtesy*: AMT 2012).

FIGURE 33 AMT LED sign (*Courtesy*: AMT 2012).

FIGURE 34 AMT rail display signs (*Courtesy*: AMT 2012).

FIGURE 35 LYNX electronic sign at Orlando International Airport (*Courtesy*: LYNX 2012).

FIGURE 36 Electronic sign in Tampere, Finland (*Courtesy*: Carol Schweiger 2009).

FIGURE 37 Electronic sign in Tampere, Finland (*Courtesy*: Carol Schweiger 2009).

FIGURE 38 Electronic sign in Mantova, Italy (*Courtesy*: Carol Schweiger 2008).

FIGURE 39 Electronic sign in Verona, Italy (*Courtesy*: Carol Schweiger 2008).

The number of lines of text available on each type of electronic sign varies as well. Indoor LED signs deployed by the respondents have between 1 and 11 lines, outdoor LED signs have between 1 and 12 lines, and both indoor and outdoor LCD signs have from eight to a configurable number of lines. The number of characters per line of text are available on each type of electronic sign varies. For indoor LED signs, the number of fixed characters per line varies from 20 to 80; outdoor LED signs from 14 to 150; and indoor and outdoor LCD signs from 10 to a configurable number. More characters can be displayed if scrolling is enabled.

The character height of the text displayed on each type of electronic sign ranges from 1.5 to 4 in. for indoor LED signs, from 1 to 4 in. for outdoor LED signs, and from 1 in. to a customizable height for indoor and outdoor LCD signs.

The text colors used on each type of electronic sign are green, yellow, red, amber, white, and black for LED signs, and a full color palette for LCD signs.

Figure 40 shows the distribution of what can be displayed on each type of sign.

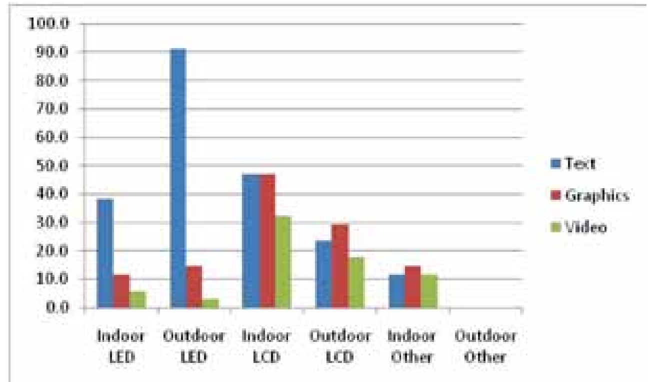

FIGURE 40 Percentage of respondents with signs that can display text, graphics, and video.

Figure 41 shows the percentage of respondents that have signs that support multiple languages.

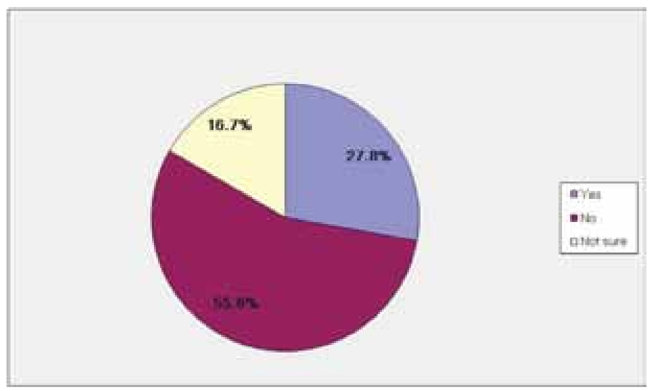

FIGURE 41 Percentage of respondents with signs that support multiple languages.

Table 7 presents the type of communication technology used for each sign type.

TABLE 7
PERCENTAGE OF RESPONDENTS USING COMMUNICATION TECHNOLOGY

Sign Type	RS-232	RS-422	Ethernet - wired	Ethernet - fiber	Radio	Cellular	Other
Indoor LED	6.7	10.0	20.0	13.3	3.3	6.7	0.0
Outdoor LED	6.7	10.0	26.7	16.7	20.0	43.3	3.3
Indoor LCD	0.0	0.0	40.0	10.0	3.3	6.7	13.3
Outdoor LCD	0.0	0.0	20.0	3.3	3.3	10.0	6.7
Indoor Other	0.0	0.0	10.0	0.0	0.0	0.0	3.3
Outdoor Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 8 shows the number of respondents that have signage with internal diagnostics and is capable of sending information to a central location (e.g., sign "health").

TABLE 8
PERCENTAGE OF RESPONDENTS WITH SPECIFIC SIGN CHARACTERISTICS

Sign Type	Internal Diagnostics	Can Send Information
Indoor LED	20	20
Outdoor LED	56	64
Indoor LCD	32	36
Outdoor LCD	20	24
Indoor Other	4	4
Outdoor Other	0	0

Table 9 shows the distribution of the type of power provided for the signage. As expected, the majority of respondents use power directly from the power grid available at the sign location.

TABLE 9
PERCENTAGE OF RESPONDENTS WITH SIGNAGE POWER

Sign Type	Direct power from power grid at sign location	Direct power from other source at sign location	Solar power
Indoor LED	35.5	6.5	0.0
Outdoor LED	77.4	25.8	3.2
Indoor LCD	35.5	16.1	0.0
Outdoor LCD	22.6	9.7	0.0
Indoor Other	6.5	3.2	0.0
Outdoor Other	0.0	0.0	0.0

INFORMATION CHARACTERISTICS

The survey covered several characteristics of signs, including the types of information provided on signs; the content, format, and accessibility of the displayed information; standards; and the reliability and accuracy of the information. First, Table 10 shows the survey results for the types of transit information provided on electronic signage. As expected, the most prevalent type of information is next vehicle arrival/departure prediction time, with identification of service disruptions and emergency information being the next most prevalent.

Second, the frequency with which the information displayed on electronic signage is updated is shown in Table 11.

Third, the number of respondents that provide the information displayed on electronic signage also on other media is shown in Table 12. The other media that is used most often is the Internet, followed by the mobile web/Internet. One noteworthy result of this survey question is the number of respondents that provide their information through a data feed for independent developers (which is the third-most-used alternate dissemination media). This supports one of the major conclusions of *TCRP Synthesis 91*, which states that "the open data trend in public transit is significant" (*1*, p. 52).

TABLE 10
TYPES OF TRANSIT INFORMATION PROVIDED ON ELECTRONIC SIGNAGE

Transit Information Type	Response Percent	Response Count
Next vehicle arrival/departure prediction time	96.8%	30
Identification of service disruptions	67.7%	21
Emergency information (e.g., evacuation due to fire)	45.2%	14
Schedule information during special events (e.g.,	41.9%	13
Information on planned detours	38.7%	12
Real-time vehicle location	29.0%	9
Availability of information and dissemination media	25.8%	8
Public service announcements	25.8%	8
Advertising	19.4%	6
Real-time information on availability of elevators and	12.9%	4
Map of area around stop/station	9.7%	3
Vehicles/routes available for transfer	9.7%	3
Number of cars on the next train	6.5%	2
Parking availability	3.2%	1
Station map	3.2%	1

The survey asked respondents to provide the format of each type of message displayed on electronic signage (e.g., "Line/No. Cars/Destination/Minutes" or "Route/Destination/Arrival Time"). The format of each type of message displayed on electronic signage is reported to be as follows:

- For each vehicle, route, or line number, destination (or direction) and number of minutes until the vehicle arrives or departs or "due"
- Problem description/comments in the case of a disruption
- Bikeshare station/number of bikes/number of docks
- Next bus stop
- Number of train arriving
- Information on special events.

The text displayed on the signage as a vehicle arrives, boards, and departs is reported in the following ways:

- Upon approach, the train info changes from green to yellow, and the arrival time flashes. Upon arrival, the flashing time goes steady. After 10 seconds, the info is removed from the sign.

TABLE 11

FREQUENCY OF INFORMATION UPDATES USED BY PERCENT OF RESPONDENTS

Transit Information Type	Update on an on-going basis (as information changes)	Update per defined threshold (e.g., every two minutes)	Update manually	Update when underlying information is not available to display (e.g., arrival time prediction not available)
Next vehicle arrival/departure prediction time	63.3	40.0	0.0	10.0
Real-time vehicle location	20.0	10.0	0.0	0.0
Availability of information and dissemination media	10.0	0.0	20.0	3.3
Identification of service disruptions	20.0	10.0	43.3	3.3
Information on planned detours	16.7	10.0	23.3	0.0
Schedule information during special events (e.g., Boston Marathon)	13.3	3.3	23.3	0.0
Emergency information (e.g., evacuation due to fire)	6.7	3.3	30.0	0.0
Vehicles/routes available for transfer	0.0	6.7	3.3	0.0
Real-time information on availability of elevators and escalators	3.3	3.3	3.3	0.0
Number of cars on the next train	0.0	6.7	0.0	0.0
Wi-Fi access points and real-time information on availability	0.0	0.0	0.0	0.0
Parking availability	0.0	3.3	0.0	0.0
Station map	0.0	0.0	3.3	0.0
Map of area around stop/station	3.3	3.3	3.3	0.0
Public service announcements	6.7	6.7	10.0	0.0
Advertising	3.3	3.3	16.7	0.0

TABLE 12

PERCENTAGE OF RESPONDENTS USING OTHER DISSEMINATION MEDIA

Trnsit Information Type	Internet accessed by personal computer	Mobile web/ internet	Data feed for independent developers	Interactive voice response (IVR)	Smartphone applications	Two-way text messaging (SMS)	Subscription alerts
Next vehicle arrival/departure prediction time	77.8	85.2	44.4	33.3	55.6	55.6	29.6
Real-time vehicle location	40.7	44.4	22.2	3.7	33.3	7.4	0.0
Availability of information and dissemination media	29.6	25.9	7.4	0.0	3.7	0.0	7.4
Identification of service disruptions	59.3	44.4	29.6	11.1	14.8	11.1	25.9
Information on planned detours	48.1	29.6	14.8	7.4	148	0.0	18.5
Schedule information during special events (e.g., Boston Marathon)	51.9	33.3	18.5	11.1	7.4	3.7	14.8
Emergency information (e.g., evacuation due to fire)	18.5	18.5	7.4	3.7	7.4	3.7	3.7
Vehicles/routes available for transfer	22.2	11.1	7.4	7.4	7.4	3.7	3.7
Real-time information on availability of elevators and escalators	7.4	7.4	7.4	0.0	0.0	0.0	0.0
Number of cars on the next train	3.7	3.7	3.7	0.0	0.0	0.0	0.0
Wi-Fi access points and real-time information on availability	3.7	0.0	0.0	0.0	0.0	0.0	0.0
Parking availability	3.7	3.7	0.0	0.0	3.7	3.7	0.0
Station map	11.1	7.4	0.0	0.0	3.7	0.0	0.0
Map of area around stop/station	25.9	11.1	0.0	0.0	7.4	0.0	0.0
Public service announcements	14.8	11.1	0.0	0.0	0.0	0.0	3.7
Advertising	3.7	0.0	0.0	0.0	3.7	0.0	0.0

- For Bus: Due, and For Train: Due (when arrival is under approximately 90 seconds), Dprt (when a train should be departing or has likely departed between data refresh).
- Arrivée: 5 min (Arrival), Train en gare (in station).
- A bus icon is displayed.
- On arrival the destination and train length are shown, possibly alternating with transfer advice. As train departs, estimated times of arrival (ETAs) for following trains are shown.
- At start of route: Departing, at midpoints: Approaching, Arriving.
- DUE when bus is less than 90 seconds away from stop, clears down when departed.
- Arrival time if available in countdown format; scheduled time if real-time is not available
- Bus Approaching.
- Route/line, destination, platform (if rail vehicle) and arrival or departure time. Words such as "Due" or "Arriving" are used when the vehicle arrival is imminent. "Departed" or next vehicle arrival/departure shown when vehicle has departed the stop/station.

The messages displayed on the signage in the event of service disruptions, and how the message is generated (e.g., automatic, manual dispatch) is reported in various ways as follows:

- Depends on the emergency or reroute. The dedicated Announcers group launches ad hoc messages using preapproved verbiage.
- Manually generated (by dispatch in some cases), and available through Website alerts system. Typically, the message is specific to the incident, and often includes location, direction, deviation, cause, and likely length of delay.
- Retardé (delayed)

Retardé à 00:00 (delayed until ...)

Annulé (canceled)

Emb. Quai 2 (Boarding on platform 2)

Board. Platf. 2 (message displayed in English)

Info message

Le train ne s'arrêtera pas à la gare xyz (Train will not stop at station xyz)

Le service de train est annulé pour une durée indéterminée. S.v.p. utilisez les services alternatifs d'autobus ou du métro ... (Train service is canceled for an undetermined time. Please use alternate bus or métro services)

L'AMT s'excuses des inconvénients (AMT apologies for the inconvenience)

Serv. alternatif (Alternate service)

Service local (Local service)

Le service de train est annulé. La gare doit être évacuée..., Train service is canceled. The station must be evacuated (this message displayed in English)—messages generated manually through Dispatch.

- The information is removed from the display when there is a disruption.
- Scrolling text is displayed after the predictions are displayed. The sequences are in the following loop. (prediction-messages-time-Web site url).
- *** Refer to Schedule ***, generated automatically after 3 min of no updates.
- "Accident on Red line please expect delays" (other custom messages can be sent).
- Passengers are advised that Routes #4 &#5 are being delayed because of ongoing construction on South Street.

When real-time information is not available, the majority of respondents reported that they display schedule-based information. Some of these respondents indicate that it is scheduled time and others (6 of the 28 agencies that responded to this survey question) do not provide any indication that it is not real-time. Other displays include the following:

- Date and time only.
- Explanation that this is the case on bus shelters; at rail stations information simply will not appear.
- Safety/passenger info animations.
- The information is simply removed from the display.
- The message "Real-time predictions are not available" is displayed.
- During a prolonged outage, frequency information may be displayed on some of the signs.
- Use the icon of a clock that represents that the display is scheduled time and not predictive time.
- Thank You for riding [Transit Agency Name].

Table 13 shows the number of respondents that provide the information displayed on the signage in audio format. Respondents report that audio is provided mostly with LED signage.

TABLE 13
PERCENTAGE OF RESPONDENTS PROVIDING INFORMATION IN AUDIO FORMAT

Sign Type	Percent of Respondents
Indoor LED	25.8
Outdoor LED	48.4
Indoor LCD	3.2
Outdoor LCD	6.5

As shown in Figure 42, when audio is provided with the signage, the most-used method is a pushbutton that allows the customer to hear what is displayed on the sign on-demand.

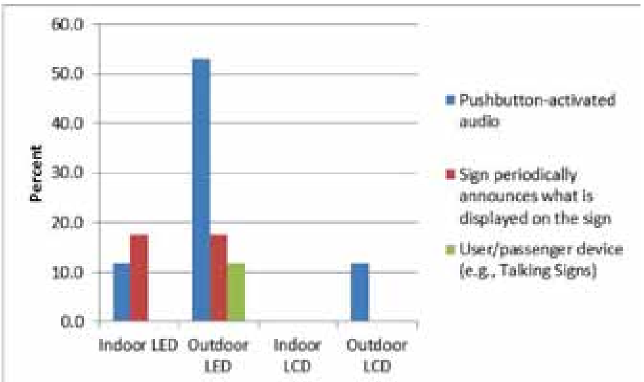

FIGURE 42 Percentage of respondents using specific methods to provide audio information.

The frequency with which the information displayed on the signage is announced (when audio is provided) varies among the respondents as follows:

- Varies on location/train activity-approaching trains are announced, configurable from 3 to 4 min
- On cue from specific events.
- Higher priority messages are shown more frequently.
- Sign is used to show text of announcements [approaching/arriving and public service announcements (PSAs)]. When there is text displayed, there is an announcement made and vice versa.
- As the sign updates, approximately every minute.
- Once every 2 min.
- As information is scrolling, audio is activated.
- On train movement but at least once every 3 min..

Figure 43 shows U.S. respondents' awareness of the Americans with Disabilities Act Accessibility Guidelines (ADAAG) regarding signage (e.g., requirements for mounting height based on horizontal viewing distance and character height).

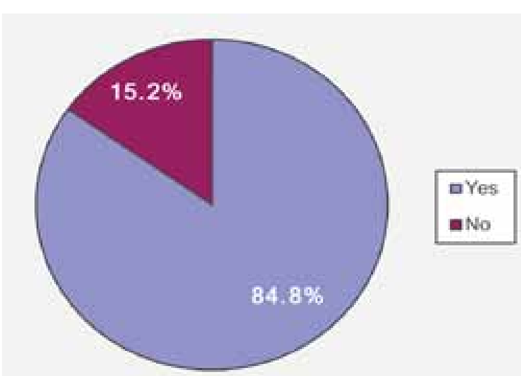

FIGURE 43 Percentage of respondents aware of ADAAG regarding signage.

Table 14 shows the ADAAG requirements used to determine the mounting and display characteristics of the electronic signs.

TABLE 14
PERCENTAGE OF RESPONDENTS USING ADAAG TO DETERMINE MOUNTING AND DISPLAY CHARACTERISTICS*

Answer Options	Response Percent	Response Count**
Mounting Location and Height	95.5	21
Character Height	90.9	20
Character Proportion	63.6	14
Finish and Contrast	63.6	14
Illumination Levels	59.1	13

*Canadian and U.K. respondents do not use the ADAAG.
**Twenty-two agencies responded to this survey question.

The reference to the ADAAG is for guidelines on how character height is to be determined. Table 15 shows the ADAAG guidelines regarding minimum character height based on DMS mounting height and horizontal viewing distance.

TABLE 15
ADAAG GUIDELINES* FOR MOUNTING SIGNS TO ENSURE LEGIBILITY OF CHARACTERS

Height to Finish Floor or Ground From Baseline of Character	Horizontal Viewing Distance	Minimum Character Height
40 in. (1,015 mm) to less than or equal to 70 in. (1780 mm)	less than 72 in. (1830 mm)	5/8 in. (16 mm)
	72 in. (1830 mm) and greater	5/8 in. (16 mm), plus 1/8 in. (3.2 mm) per foot (305 mm) of viewing distance above 72 in. (1830 mm)
Greater than 70 in. (1,780 mm) to less than or equal to 120 in. (3,050 mm)	less than 180 in. (4570 mm)	2 in. (51 mm)
	180 in. (4570 mm) and greater	2 in. (51 mm), plus 1/8 in/ (3.2 mm) per foot (305 mm) of viewing distance above 180 in. (4570 mm)
Greater than 120 in. (3,050 mm)	less than 21 ft. (6400 mm)	3 in.(75 mm)
	21 ft. (6400 mm) and greater	3 in.(75 mm), plus 1/8 in. (3.2 mm) per foot (305 mm) of viewing distance above 21 ft. (6400 mm)

* Refer to character height information in Section 703.55: http://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm#pgfId-1010471 [accessed April 2011].

Table 16 shows the data exchange standards being used by the respondents to provide transit information on electronic signage.

TABLE 16
USE OF DATA EXCHANGE STANDARDS

Data Exchange Standards	Response Percent
General Transit Feed Specification (GTFS)	39.1
Transit Communications Interface Profiles (TCIP)	34.8
Service Interface for Real Time Information (SIRI)	26.1
NextBus Public XML Feed	21.7
Clever Devices API	17.4
GTFS-real time	13.0
Standard Object Access Protocol (SOAP)	13.0
Representational State Transfer (REST)	13.0
Java Script Object Notation (JSON)	4.3

Other standards reported by respondents include the following:

- In-house program developed by Siemens.
- Custom built internal sign API; custom train arrivals API (both REST).
- XML from different industry sources.
- Vendor provided interfaces (INIT).
- Capital Bikeshare data feed.
- Web services developed by our web provider, but not sure which technology is used.
- XML (Non-NextBus).
- Internal Developed Transmission Control Protocol/Internet Protocol.
- RTIG Server to Server, TransXChange.
- XML for custom interfaces.
- Proprietary interface.
- Unsure—from ACS CAD/AVL OrbCAD system.

The survey asked how the accuracy and reliability of the information provided through electronic signs is ensured. Answers included the following:

- Automated means:
  - Based on an automatic train system (ATS) system that tracks trains in real time. The system is constantly monitored from the central center as well as personnel in the field. Customer comments sent to the website are also evaluated.
  - We have a monitoring interface that acquires predictions every minute for two stops of every bus line. We compile the stats on various aspects so we are able to [review] an overview of the system's performance.
  - Automated notice of any interruption in service.
- Manual means:
  - Spot checking, user feedback is thoroughly investigated
  - Rely on people checking either within a control center or at a station that all information is consistent
  - Manual checks/visual inspection and customer feedback
  - Field observations
  - Occasional surveys.
- Other:
  - Virtual Private Network access, screen shot through software, periodical site visits
  - Rely on the various transit agencies for the accuracy of data they provide
  - Remotely logging in and cross-referencing the arrival times with the CAD/AVL display
  - Data quality checks.

Table 17 shows the percentage of respondents that measure the amount of time the system is available, accurate, and reliable.

TABLE 17
SYSTEM AVAILABILITY, ACCURACY, AND RELIABILITY

Measure	Reported
Time that real-time information system is operational as a percent of total transit operating time	Reported as 92% to 100% operational
Accuracy (e.g., ±1 min within 5 min to arrival, ±2 min within 5–10 min to arrival, ±5 min beyond 20 min to arrival)	• Variety of responses: • The first threshold is ±30 s for 5 min; the second threshold is ±120 s for 5–10 min; the third threshold is ±200 s for 10–20 min; and the fourth threshold is ±300 s for 20–30 min • ±1 min within 5 min to arrival • ± 2 min within 5 min to arrival
Reliability—system is operating within the above accuracy standards a certain percent of the time	From 90% to 100% of the time

CHAPTER FOUR

RESOURCE REQUIREMENTS

Responses to the questionnaire regarding the resources and costs associated with implementing electronic signage yielded limited information. To determine the labor required to support implementing electronic signage, the survey explored the transit agency departments involved in various stages of implementation: planning, developing requirements/specifications, procurement, installation, operations, placing messages on the signage, maintenance, and responding to customers. The information technology (IT) department was most often the department responsible for the implementation of electronic signage, with operations and planning as the next departments responsible for implementation.

Table 18 shows how the capital cost of each type of sign widely varied among the respondents.

TABLE 18
CAPITAL COSTS

Sign Type	Number of Respondents	Cost Range (per sign)
Indoor LED	5	$200 to $12,500
Outdoor LED	18	$1,500 to $17,000
Indoor LCD	6	$500 to $5,000
Outdoor LCD	4	$1,500 to $10,000

For signs, four respondents reported costs ranging from per sign. These wide variations in cost are the result of a number of factors—the number of lines and characters available, the colors used, and the like.

A limited number of respondents reported the per-unit annual operating and maintenance cost of each type of sign. Two respondents reported that the annual operations and maintenance cost of an indoor LED sign is from $40 to $1,000. Eleven respondents reported a range from $0 to $1,000 for an outdoor LED sign. Three respondents reported a range of $30 to $300 for an indoor LCD sign, and two respondents reported $50 and $300 for an outdoor LCD sign. Please note that international agency responses were in line with those from the United States.

Similarly, a limited number of respondents provided the per-unit monthly communication costs. For indoor LED signs, three respondents reported a range of $10 to $46. Thirteen respondents reported a range of $0 to $192 per month for outdoor LED signs. For indoor LCD signs, five respondents reported $0 and one reported $10 per month. For outdoor LCD signs, four respondents reported from $0 to $10 per month. One respondent mentioned a challenge using wireless communication (including radio) and solutions unless the sign is displaying only text.

An even lower number of agencies reported information on the per-unit monthly cost for powering the signs. Two respondents reported that indoor LED sign power costs $0

TABLE 19
DISTRIBUTION OF RESPONSIBILITIES AMONG STAFF (PERCENTAGE OF RESPONDENTS)

Signage Activities	Information technology	Operations	Training	Marketing/ Communications	Human resources	Planning	Maintenance	Procure-ment/Legal	Customer Service
Planning for the signage	51.9	37.0	0.0	33.3	3.7	51.9	7.4	0.0	11.1
Developing requirements/ specifications of the signage	63.0	33.3	0.0	29.6	0.0	33.3	7.4	3.7	7.4
Procuring the signage	37.0	22.2	0.0	7.4	0.0	22.2	3.7	48.1	3.7
Installing the signage	37.0	18.5	0.0	0.0	0.0	18.5	40.7	14.8	0.0
Operating the signage	40.7	59.3	0.0	11.1	0.0	22.2	14.8	0.0	11.1
Placing messages on the signage	22.2	70.4	3.7	37.0	0.0	18.5	0.0	0.0	25.9
Maintaining the signage	40.7	22.2	0.0	0.0	0.0	11.1	55.6	0.0	0.0
Responding to customer complaints about accuracy of information	51.9	37.0	0.0	22.2	0.0	18.5	11.1	0.0	33.3
Other	7.4	0.0	0.0	0.0	0.0	3.7	0.0	0.0	3.7

and $2 per month. For outdoor LED signs, the power cost reported by five respondents varied from $2 to $50 per month. For indoor LCD signs, the power cost was reported by three respondents as from $0 to $5 per month. Three respondents reported a monthly power cost of $0 to $20 for outdoor LCD signs.

In terms of resources, Table 19 shows the distribution of responsibilities among agency staff for various activities associated with planning and deploying electronic signage.

When asked about the labor hours spent by each department/staff that are involved in the deployment of electronic signage, only 15 respondents offered estimates, as shown in Table 20. For IT staff, 10 respondents reported that the number of labor hours per month ranged from 2 to 80. For Operations staff, nine respondents report a range of 2 to 40 labor hours per month. Marketing Communications staff labor range from 1 to 20 labor hours per month, as reported by five respondents. Planning staff hours range from 1 to 80 hours, as reported by six respondents. Maintenance staff spends between 1 and 60 hours per month, as reported by six respondents. One respondent reports that Legal/Procurement staff spends 3 hours a month, and three respondents report that Customer Service staff spends from 1 to 20 hours per month.

TABLE 20

MEDIAN NUMBER OF LABOR HOURS PER MONTH FOR STAFF RESPONSIBLE FOR SIGN OPERATIONS AND MAINTENANCE

Responsible Department	Median Labor Hours per Month
Maintenance	15.0
Customer service	10.0
Information technology	8.5
Operations	6.0
Planning	4.5
Procurement/legal	3.0
Marketing/communications	2.0

CHAPTER FIVE

DECISION PROCESS FOR ELECTRONIC SIGNAGE DEPLOYMENT

One hypothesis considered as part of this Synthesis was that the implementation of electronic signage contributes to an agency's overall communications strategy. This section describes the contribution of electronic signage in several ways. First, it covers several decision criteria associated with determining if electronic signage is to be deployed. Second, it mentions whether or respondents have a communications strategy, along with whether deploying electronic signage is part of that strategy. Third, it presents responses on "information equity." Fourth, it discusses whether the deployment of electronic signage resulted in an increase in ridership. Fifth, it describes the use of marketing to inform customers about signage and customers' reactions to signage. Finally, it discusses considerations of including advertising on electronic signage.

DECISION CRITERIA

The survey covered the reasons for implementing electronic signage, as well as whether or not a study was conducted before deploying the signage and the criteria used to determine where to place electronic signage. First, as shown in Table 21, the survey results indicated that nearly all respondents decided to deploy electronic signage to increase customer satisfaction. Just over 70% of the respondents reported that signage was deployed both to improve the perception of the transit system and supplement other methods of disseminating information. The next two most prevalent reasons are "because we are a progressive agency" and "we want to keep up with current technology." One response of note is that not quite half of the respondents deploy electronic signage to increase ridership.

Second, in terms of conducting a study to determine if signage should be deployed, just over half of the respondents did *not* conduct a study. For those that did conduct a study, the most prevalent type of study was a business case analysis. Also, the following types of studies were reported:

- Conducted research into best practices.
- Used a pilot project to determine the technical feasibility for outdoor LCD signs.
- Visited other transit agencies where similar systems were implemented.
- Conducted rider surveys.
- Conducted an IT deployment study to determine what technology to use (more general than a specific sign study).
- Assessed customer demand.
- Conducted research with other agencies; conducted market analysis.
- Conducted an ITS investment study.

TABLE 21
REASONS FOR DEPLOYING ELECTRONIC SIGNAGE

Motivation for Deploying Electronic Signage	Response Percent
Increase customer satisfaction	97.3
Improve perception of transit system	70.3
To supplement other methods of disseminating information	70.3
Because we are a progressive agency	59.5
We want to keep up with current technology	51.4
Increase ridership	48.6
Received funding to deploy signage	32.4
Customers requested the signs	18.9
Part of a subway, light rail/streetcar, or BRT project	16.2
Influenced by other agencies' deployment of signage	5.4

Other:
- Part of an overall ITS communication strategy.
- To take advantage of real-time open data across several transit modes.
- We wanted to change the customer's perception of the waiting time.
- Part of larger ITS procurement.

Finally, the criteria used to locate the signage are shown in Table 22. As expected, boarding counts at stops/stations is most used as a criterion to determine where to place electronic signage. Next most prevalent criteria are the availability of power, followed by the number of lines/routes at stop/station.

COMMUNICATIONS STRATEGY

Sixty-seven percent of the survey respondents have a communications strategy. Of those, 82% consider electronic signage to be part of that strategy. Further, 70% of the respondents consider providing transit information on electronic signage as a way to attract "choice" riders.

INFORMATION EQUITY

The survey explored "information equity," which is defined as providing real-time transit information by means of at least two dissemination media, and in both audio and visual formats. Given that this study is focusing on a primarily visual dissemination media, it was important to determine if consideration was given to providing information displayed on a sign in audio format. The results of the survey showed that the overwhelming majority of respondents (almost 90%) consider providing real-time transit information by means of at least two dissemination media. Further, more than 65% of the respondents consider providing real-time information in *both* audio and visual formats.

TABLE 22
LOCATION CRITERIA

Location Criteria	Response Percent
Boarding counts at stops/stations	67.9
Availability of power	57.1
Number of lines/routes at stop/station	53.6
Availability of communication	42.9
Number of transfers at stop/station	39.3
Signs at all BRT/light rail/subway/commuter rail stations	35.7
Physical obstructions/visibility	32.1
Mounting infrastructure	32.1
Safety considerations	25.0
Security considerations	21.4
Outdoor versus indoor mounting needs	14.3
Environmental considerations	10.7
Existence of alternate media to provide transit information	7.1

Other: Reasonable coverage per platform for passenger visibility of signs:
- Political (ward) considerations.
- Locations throughout the community. Beta sites are in offices and retail stores.
- Title VI.
- At major BRT stations based on boardings.
- Standard Rail Station feature.

INCREASE IN RIDERSHIP

The survey included a question that is typically asked in a discussion about the effects of providing real-time information: "Did the deployment of electronic signage to display transit information result in an increase in ridership?" As reported in prior real-time information studies, 66.7% of respondents do not know if there was an increase in ridership as a result of deploying electronic signage.

MARKETING AND CUSTOMER REACTIONS

The survey then explored the use of marketing to inform and promote the use of electronic signage. Only 33.3% of respondents reported that they had developed a marketing campaign specifically about electronic signage to provide transit information.

Agencies were asked about how they gauge the customers' reactions to the electronic signage. As shown in Figure 44, more than 90% of respondents reported that they determine customer reactions to the signage by receiving compliments or complaints. And as expected based on the discussion of ridership earlier, a small percentage of respondents actually measure changes to ridership after electronic signs are deployed. One agency noted that positive customer comments were made as the agency was finalizing installation and performing testing in stations.

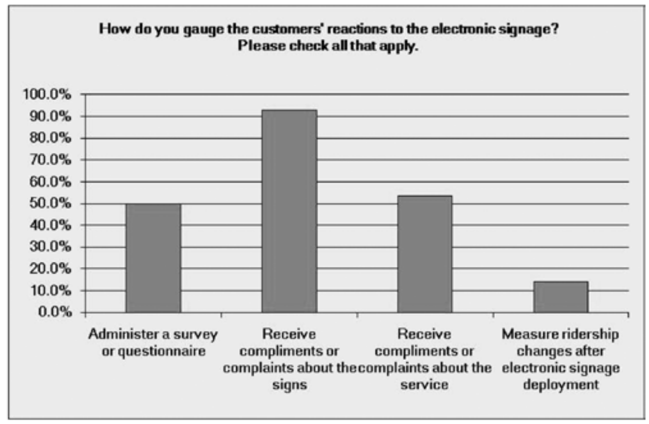

FIGURE 44 Determination of customer reactions to signage.

ADVERTISING

There were several questions regarding the use of advertising on electronic signs. Only one respondent reported that they include advertising on the same electronic signage that provides passenger information. (The next chapter contains a discussion about CTA, including real-time information with advertising on electronic signs.) The reasons that were provided for not including advertising on electronic signage are as follows:

- Advertising conflicts with displaying real-time information.
- Advertising takes away the essence and visibility of the critical information. The primary function of the signs is to disseminate train arrival information.
- Signs in use are not advertising-friendly.
- Difficulty of administering with minimal perceived value.
- There has not been a demand.
- Legal or code constraints.
- Advertising is prohibited by the jurisdiction where signs located.
- Based on research that says that information needs to be kept separate from advertising. Anecdotal experience shows that where advertising "pays" for signs, it is not a sustainable model.

Another advertising-related question was "does your agency offer location-specific advertising on electronic signs (i.e., buy ads on a particular sign for a nearby business)?" All respondents answered "no."

CHAPTER SIX

CASE EXAMPLES

Several of the transit agencies and organizations that responded to the Synthesis survey were interviewed by telephone in order to obtain more detailed information on their deployment of electronic signage. This section presents results of the interviews as case examples.

TRI-COUNTY METROPOLITAN TRANSPORTATION DISTRICT OF OREGON (TRIMET) (PORTLAND, OREGON)

TriMet's commitment to electronic signage was described in *TCRP Synthesis 48* (*43*).

> Tri-Met has a three-pronged approach to providing real time bus arrival information. First, they are beginning to provide real time bus arrival information on LED signs at bus stops. As of September 2002, 11 signs have been deployed at ten 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. (*43*, pp. 37–38)

TriMet's plans changed considerably regarding the deployment of LED signs. As discussed in *TCRP Synthesis 91* (*1*, pp. 38–40), in 2005, TriMet conducted an on-street survey of riders and determined that 70% of riders had mobile phones. So, the focus of providing real-time information to customers shifted to placing real-time information on TriMet's website and on an interactive voice response (IVR) system, and eventually on mobile devices. So, TriMet has considerable experience with electronic signage over the past 10 years. This case example covers their experiences and lessons learned.

The first LED sign installation was in 2001, coinciding with the start of the Airport MAX Red Line (one of Portland's light rail lines). At the same time, TriMet worked with the bus CAD/AVL vendor (Orbital Sciences at that time) to provide real-time information on DMS. TriMet believed that placing signs at bus stops with high ridership would provide benefits. They started with one-line LED signs and built the cases for the signs themselves (no cases were needed for indoor LED signs). These bus stops signs used cellular digital packet data (CDPD) modems to receive the information displayed on the signs. Figures 45 and 46 show original LED signs installed in a bus shelter.

FIGURE 45 Dynamic message sign in TriMet bus shelter.

FIGURE 46 Single-line LED DMS in TriMet bus shelter (*Courtesy*: TriMet).

TriMet executives were excited about the signs, and the deployment program went ahead as described in *TCRP Syntheses 48* and *91* (*43*, 1). However, in 2005, management decided that they would no longer pay monthly fees for the sign communications—it cost approximately $50 per month per sign for the CDPD communication—and at the same time, cellular providers were discontinuing the use of CDPD for better and faster technology [e.g., short message service (SMS), general packet radio services (GPRS) and 3-G technologies]. Further, TriMet management was happy about the implementation of Transit Tracker (TriMet's real-time information system) by phone, so TriMet removed the CDPD modems. If the electronic signs did not have free communication (Wi-Fi), bus signs were removed. In the downtown area, there was a free Wi-Fi connection to offices downtown, but eventually that Wi-Fi connection no longer existed; therefore, the signs located within close proximity to this Wi-Fi connection were removed. Figures 47 and 48 show newer LCD signs that have been installed in bus shelters.

FIGURE 47 TriMet LCD DMS at bus stop near Lloyd Center (*Courtesy*: Carol Schweiger 2011).

FIGURE 48 TriMet LCD DMS at bus stop near Lloyd Center (*Courtesy*: Carol Schweiger 2011).

There were some issues with the original bus DMS deployed in 2001–2002—mostly related to anomalies when bus CAD/AVL system logins failed, bus breakdowns occurred, and there were missed pullouts, which meant that that particular vehicle was not reporting to the CAD/AVL system. As reported in *TCRP Synthesis 48*,

> Tri-Met does not use a prediction algorithm per se to calculate real time arrival information that is displayed on the LED signs. Information that is sent to each bus driver through a mobile data terminal (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's processor applies the information about arrival time to the schedule to determine the offset from the schedule. This is a distributed, decentralized system, since information that will be used to determine arrival times is sent to the sign for processing. (*43*, p. 38)

Since then, this information processing has become centralized.

Portland's Transit Mall was rebuilt and reopened in 2009. When it reopened, older DMS signs were taken out (they only showed schedule times). These signs (shown in Figure 49) required quite a bit of maintenance, but 97% of people at the Transit Mall regularly or often consulted these signs, so new DMS were installed such as the sign (shown in Figure 50). These LCD signs include a pushbutton to provide the sign's information in audio, as shown in Figure 51. The sign pushbuttons were added after the sign design was completed.

FIGURE 49 Original DMS showing scheduled times on transit mall (*Courtesy*: TriMet).

FIGURE 50 LCD DMS on transit mall (*Courtesy*: TriMet).

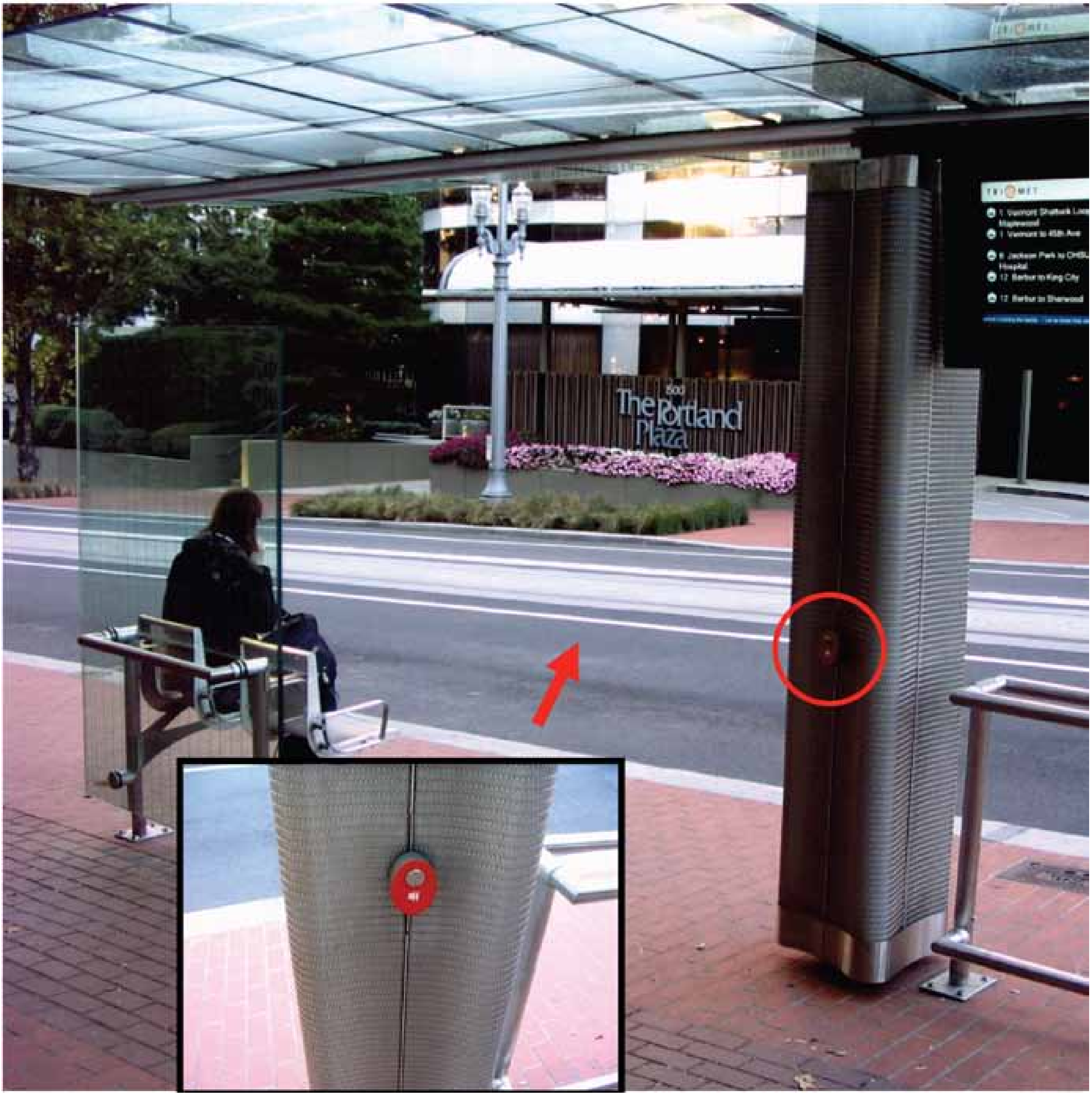

FIGURE 51 Pushbutton to obtain audio version of LCD display (*Courtesy*: TriMet).

A 2006 study (*36*, p. 47) supported the idea that many TriMet customers used the electronic signs. "Passenger surveys indicate that 78% of riders at Transit Tracker Equipped bus stops use the information frequently or almost always, 11% on an infrequent basis and a further 11% rarely or almost never." Further, "a number of conservative assumptions are considered to calculate a minimum estimated number of trips using Transit Tracker information, as shown in Table 23. It is conservatively estimated that Transit Tracker is likely used for at least 20 million bus and rail trips each year. Even if use at rail stations is excluded from the analysis, transit tracker information is likely used by an estimated 3.4 million trips per year."

The excitement about electronic signs actually started earlier with the opening of the Red line a few days after September 11, 2001. At that time, LED signs were put in a few rail stations. Also, as part of the construction of the stations, DMS were installed at several park-and-ride lots above rail stations using Wi-Fi from the rail platform. Four-line DMS on the light rail platforms required a column that cost $5,000 per column, so the cost of the columns had to be included in the budget for DMS on light rail platforms. Figure 52 shows one of these DMS.

TABLE 23
ESTIMATED ANNUAL NUMBER OF TRIPS USING TRANSIT TRACKER INFORMATION

Transit Tracker Information Source	Maximum Number of Trips	Assumed Usage Rate	Assumption/ Justification	Minimum Estimated Number of Trips
Transit Tracker Equipped Bus Stops	2,491,866	50%	Passenger survey result that 78% use always or frequently	1,245,933
Transit Tracker Equipped Rail Stops	181,760,400	10%	Assumes 1 in 10 riders use information display	18,176,040
Web Page	792,000	50%	Assumes 2 web hits per trip	396,000
Phone	2,678,694	67%	Assumes 1.5 phone calls per trip	1,785,796
Total Trips using Transit Tracker	187,722,960			21,603,769
Total Trips Excluding Rail	5,962,560			3,427,729

(*35*, p. 47).

TriMet's plan is to provide electronic information at every Metropolitan Area Express (MAX) rail platform to provide service disruption information. TriMet received a FTA grant for $180,000 and added $50,000 to that from local funds. This grant will be used to retrofit light rail platforms that currently have no signage, which means that 16 signs are being added. Further, LCD signs will be deployed as part of the Milwaukie light rail project.

From a multimodal perspective, TriMet installed DMS in shelters at the busiest transit location in Portland: the corner of Interstate and Lombard. Yellow line trains stop here, and there are multiple east-west bus routes. These DMS read whatever is on the sign using text-to-speech technology. One interesting aspect of TriMet's experience with DMS is that the signs were originally a pilot program—a series of experiments that were conducted internally for the most part.

As of April 2012, TriMet has 13 bus and 105 rail outdoor LED signs, and 49 bus and 35 rail outdoor LCD signs.

In summary, TriMet experienced various sign activities according to the timeline in Table 24.

FIGURE 52 DMS on light rail platform (*Courtesy*: TriMet).

TABLE 24
TRIMET SIGNAGE TIMELINE

Activity	Date
First LED sign installed	2001, coinciding with the start of the Airport MAX Red Line
11 signs installed at bus stops and 28 signs installed at MAX stops	September 2002
• Focus shifted away from deploying signs • No longer will pay monthly fees for sign communications	2005
Transit Tracker system evaluation	2006
Portland Transit Mall reopened	2009
13 bus and 105 rail outdoor LED signs, and 49 bus and 35 rail outdoor LCD signs installed	As of April 2012

REAL TIME INFORMATION GROUP—UNITED KINGDOM

The RTIG "was established in 2000 to provide a focus for all those involved in UK bus [real-time information] RTI. We now have a comprehensive remit to cover the effective and efficient use of technology in the interests of passenger transport users, operators and sponsors" (*44*). Since 2002, RTIG has conducted an annual survey that "assesses the implementation of public transport technology on buses, at stops and other locations and on other modes of transport. It focuses on the use of Automatic Vehicle Location (AVL) and the dissemination of Real Time Information (RTI). It covers the major issues which arose during implementations which had a major impact on timeliness, cost or functional delivery" (*6*, p. 1) One significant element of the surveys is reporting on the use of "RTI physical displays" throughout England, Wales, Scotland and Northern Ireland.

According to the 2011 survey (*6*, p. 22),

> at end 2011, there were approximately 8,130 bus stops fitted with 3-line or multi line LED signs and a further 2,046 fitted with full screen (LCD or plasma displays). This is equivalent to 10,176 real time information-enabled physical displays in the United Kingdom. For [Great Britain] GB, there has been an increase in sign numbers since 2005 with a particularly sharp increase between 2007 and 2008. This increase was not the result of any single implementation, but of a number of implementations around the country coming on line. Since then, GB has experienced a largely flat picture, with a small dip in 2009 accounted for by a number of non-returns. This year continues that flat picture with a fall of 116 stops fitted with RTI signs, a small fall of 1%. (*6*, p. 22)

Figure 53 that shows this trend.

> Both 3-line/multi-line LED displays and full screen displays show a very slight decline in 2011. Last year, there was growth in both types of display and the proportion of displays which were full screen rose to 20% from 18% the previous year. This year, the proportions are identical to last year. 3-line/multi-line LED remain about 80% of all RTI signs and LCDs have remained at 20% of all RTI signs. Projections last year for this year suggested that the shift from LEDs to LCDs would continue. Out of the total of 8,565 signs, it was predicted that 6,222 would be LED whereas 2343 would be LCD. This would have meant that that LCDs accounted for 27% of all RTI signs. However, this was not borne out in the actual data for this year. (*6*, p. 23)

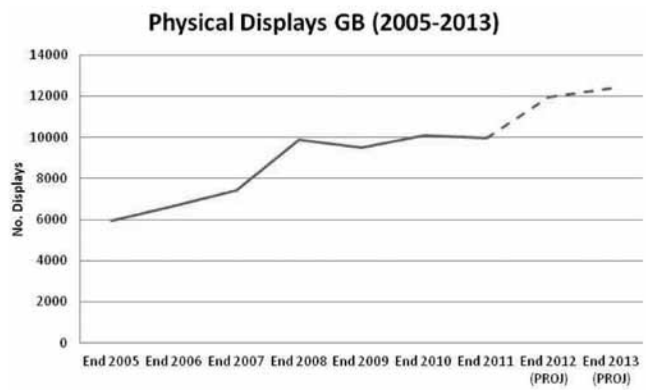

FIGURE 53 Number of signs in Great Britain. 2005–2013.

Despite the proportion of LCD signs did not increase as expected, RTIG expects that there will be significant growth in the use of LCD or full-screen displays. Up until 5 years ago, three-line LED DMS constituted most of the U.K. signage, but now full-screen LCD sign installations are more affordable. RTIG says that, generally, one-third of all installations are full-screen displays with full color. The use of full-screen displays makes it easier to program the display (e.g., you can use a browser rather than a more complex program). Further, a full-screen display provides much more space than LED signs, so much more information can be provided to the public beyond just next vehicle arrival times. An agency could not be very creative with an LED sign (e.g., only able to display "Next bus in 13 minutes").

RTIG feels that there is an impact on transit as a whole as more displays become full-screen or LCD. Once agencies use a large display, it provides the opportunity to make more use of the real estate on the sign. For example, the full-range of county services or a map could be displayed in addition to real-time textual information.

In the United Kingdom, there is a move toward providing information on mobile devices. There are four primary factors in considering this approach: (1) the cost associated with the signage; (2) the fact that there has been vandalism to electronic signs; (3) the availability of open data; and (4) the comparative of providing mobile information rather than having to equip thousands of stops. However, "information equity" is recognized in the United Kingdom in that all customers do not necessarily have mobile devices; also, when mobile devices were introduced, they were hard to use, so placing transit information on mobile devices was not common. Thus, signage remains an important dissemination media in the United Kingdom.

onetheless, there has been a generational evolution regarding the deployment of electronic signs in the United Kingdom. First, there is more access to mobile devices and individuals feel more comfortable using them. Second, funding for electronic signage is much more limited than it once was. The expense was justified in the past in that signage was considered worthwhile to the community. Third, there are some issues regarding information quality (e.g., resulting from vehicles not being logged in), necessitating an examination of the impact of "bad" information displayed on signage. Fourth, in the U.K. market, private sector operators control public transport services—the agencies that they support have no say in issues related to the use of the underlying technology that generates information that is displayed on signage. These operators may resist making changes that could affect the quality of displayed information. To address this issue, TfL has a significant quality management process in place that monitors the performance of the private operators, including their use of the underlying technology. Finally, it is thought that people expect to have detailed information at their fingertips about their travel. If this information is not provided, perceptions of the public transit service are tarnished.

In the United Kingdom, electronic signage is considered an important approach to influencing modal shift and maintaining ridership. The overall approach is to provide information that gives people travel choices, requiring methods that will attract people to public transit and influence the competition between public transit and private automobiles.

With the shift to full-screen displays in the United Kingdom, information on all travel choices can be provided. These displays will still need to be placed at carefully-chosen locations that provide the maximum impact on travel choice. Several considerations for placement include the ridership at a stop, but it is thought that high-capacity stops do not need signage because vehicles make frequent stops. However, the high-capacity stops often have the highest profiles from a political perspective. There is more need for signage at low-volume stops, but at these locations, the value of the signage per person is high, but the overall value is low. So there is still quite a bit of discussion about where electronic signs should be placed.

Full-screen displays can provide much more information on disruptions, which is relatively new to the United Kingdom. The value of providing disruption information is considered high, and was surveyed for the first time in the 2011 survey as discussed in chapter two (*6*, p. 50). As shown in Table 25, the survey respondents used several protocols with the electronic signage when there is a disruption. Further, "LAs were also asked to identify the channel(s) used at present to disseminate disruption information." Table 26 shows the breakdown of the media used. Electronic signs are the most prevalent media, followed by third-party websites and local authority websites.

TABLE 26
TYPES OF CHANNELS USED BY U.K. LAS TO DISSEMINATE DISRUPTION INFORMATION

Type of Channel	No. of LAs*
On Street Signs	43
3rd Party Websites	36
LA Websites	35
Twitter	17
Telephone Hotline	16
Facebook	8
Mobile Applications	7
SMS/WAP	7
Transport Direct Portal	5

(*6*, p. 51).
* A total of 54 LAs

CHICAGO TRANSIT AUTHORITY—CHICAGO, ILLINOIS

CTA has a communications strategy, and electronic signage is a significant part of this strategy. As of April 2012, CTA had 192 indoor LED signs, 768 outdoor LED signs and 120 outdoor LCD signs. CTA views their signage program in three parts:

TABLE 25
PROTOCOLS FOLLOWED BY U.K. LOCAL AUTHORITIES (LAS) DURING DISRUPTION*

Country	Turn On-Street Signs Off	Put on a Standard Holding Message on On-Street Signs	Give Out Real-Time Information About the Disruption on On-Street Signs	No. of Respondents
England	7	17	15	39
Wales	1	2	0	3
Scotland	0	6	4	10
UK Total	8	25	20	53

* "For true comparison, the Scottish transport partnerships were counted according to the number of LAs they explicitly mentioned representing on the survey; HiTrans represents 3 LAs, NESTrans represent 1 LA, SPT represent 3 LAs, SWESTrans represent 1 LA. SESTrans was counted as 1 LA as they responded to the survey without specifying any towns/cities." (*6*, p. 50).

1. Accessibility/upgrades—providing audio for the DMS in the 146 rail stations through integration with the public address (PA) system. Eventually, there will be 1,500 LED DMS in the rail stations. The existing (and future) signs display next train predictions and emergency messages. The existing signs in rail stations are being upgraded, as some are up to 20 years old as of April 2012. Partially owing to the signage upgrade, each station has new design criteria. And as of April 2012, one-third of stations have no signage. "CTA is also in the preliminary testing phase of displaying Train Tracker arrival times at 13 rail stations on existing LED displays" (*45*).

   As expected, signage installation in a rail environment is more expensive than that in a bus environment, but CTA has the benefit of a fiber network for communicating the information to the signs. Further, some of the display screens are not compatible with station ceilings/canopies because of aging infrastructure. New signs being obtained by CTA will be more lightweight and power-efficient.

2. Information signage at bus shelters is being implemented to display bus predictions (from CTA's Bus Tracker℠). As of April 2012, 152 LED DMS have been deployed as part of Phase 1. Figure 54 shows a bus stop LED DMS in a bus shelter outside 222 South Riverside Plaza. "Each sign is equipped with a push button and speaker to announce the estimated arrival times for our riders with visual impairments. The push button is located on one of the inner poles, closest to the street. Push the button once and a speaker inside the shelter will announce upcoming arrivals" (*46*). Figure 55 shows the pushbutton used for the CTA bus shelter DMS (mounted on shelter support pole), and Figure 56 shows the speaker located behind the electronic sign. All bus shelters with LED signs have pushbuttons to activate an audio version of the message/arrival times.

   Phase 2 will install an additional 250 LED DMS in bus shelters. This deployment is expected to begin in Summer 2012. The bus shelter DMS program is funded with $3.8 million, consisting of $1.4 million of CTA funds, a $1.8 million Regional Transportation Authority grant, and a $640,000 FTA grant.

   As of April 2012, a significant improvement is being made to the backend architecture to accommodate 400 signs. Currently, the limit is 152 signs, but CTA was not aware that this was the limit when it began the Phase 1 installation. "Those 400 shelters represent 20 percent of the bus shelters throughout Chicago, but accommodate 80 percent of the system's bus ridership, CTA President Forrest Claypool said" (*47*).

FIGURE 54 LED DMS in CTA bus shelter outside 222 South Riverside Plaza (*Courtesy*: David Phillips 2012).

FIGURE 55 Pushbutton to activate audio for CTA bus LED DMS (*Courtesy*: David Phillips 2012).

FIGURE 56 Speaker that provides audio for CTA bus LED DMS plaza (*Courtesy*: David Phillips 2012).

One complexity associated with the deployment of signage in bus shelters is that the street furniture contract is with the city of Chicago, not CTA. Three primary issues had to be addressed because of this complexity. First, some of the shelters are quite narrow, making it difficult to add the signs. Second, the operating costs associated with signs on remote shelters can be significant; for example, communication charges for LED signs can run $50 per month per sign. Finally, when there is a problem with a sign, CTA has to identify whether it is a problem with the shelter (requiring contacting the shelter vendor) itself or a problem with the sign.

3. In 2009, CTA began to implement digital advertising signs (not related to item 1 on p. 123). In rail stations, these signs can display next train arrival information (for 5 train arrivals). Because advertising on the signs takes precedence over any other information displayed on the signs, other messages, such as next train arrival can be delayed. The other messages have to fit into the signage within a certain period. CTA feels that, in a general sense, advertising and information do not mix. Further, the placement of the digital advertising may not be where customer information should be placed. The advertising company decides where the signage will be located and then has to obtain CTA approval. Finally, these signs are being installed to generate revenue, which is a different motive than providing customer information.

The plan is for more than 1,500 digital advertising signs to be installed on 100 buses and at all 144 rail stations. No real-time information will be displayed on these signs. There is no upfront cost to the CTA (*48*). With the upgrades being made to rail stations, more communication lines are being included to accommodate more advertising signs.

CTA's philosophy toward deploying DMS is multifaceted. First, CTA wants to encourage ridership and sees DMS as one way to accomplish that goal. It places a high priority on getting information into travelers' hands, empowering customers to make a decision and reducing their anxiety while traveling. Second, CTA recognizes that signage is not a "one-size fits all"—it is dependent on where the sign is located and the surrounding environment. For example, the signs that have a 16:9 aspect ratio (referring to the ratio of picture length to picture width), which is the common aspect ratio for high-definition television, have not worked as well as half-height LCD displays, which have a 16:4 aspect ratio, because of visibility. Also, CTA's approach to sign placement has evolved based on the experience of the employees in the field in terms of sign visibility, availability of necessary infrastructure (e.g., power), and the like. Third, signage is considered an "equalizer" in that CTA does not want to force customers to use a specific media (e.g., only providing information on mobile devices). Finally, CTA deploys technology deliberately and carefully. For example, Bus TrackerSM was deployed before service cuts were introduced to help people understand the new bus routes and schedules.

CTA has a do-it-yourself Transit Info Display program in beta testing. "The *Do-It-Yourself Transit Info Display* (beta) from CTA makes it easy for anyone with some computer savvy to show estimated bus arrival times on a display in a building lobby, a storefront window, inside a shop... Anywhere you like!" (*49*). Figures 57 and 58 show sample displays.

MOBILITY LAB—ARLINGTON, VIRGINIA

At the beginning of 2012, Mobility Lab (http://mobilitylab.org/) in Arlington, Virginia, announced the deployment of electronic signs that display real-time transportation information in two local establishments (a coffee shop and a bar). Mobility Lab, "an initiative of Arlington County Commuter Services, focuses on the professional discipline of Mobility

FIGURE 57 Sample DIY Train TrackerSM display (*49*).

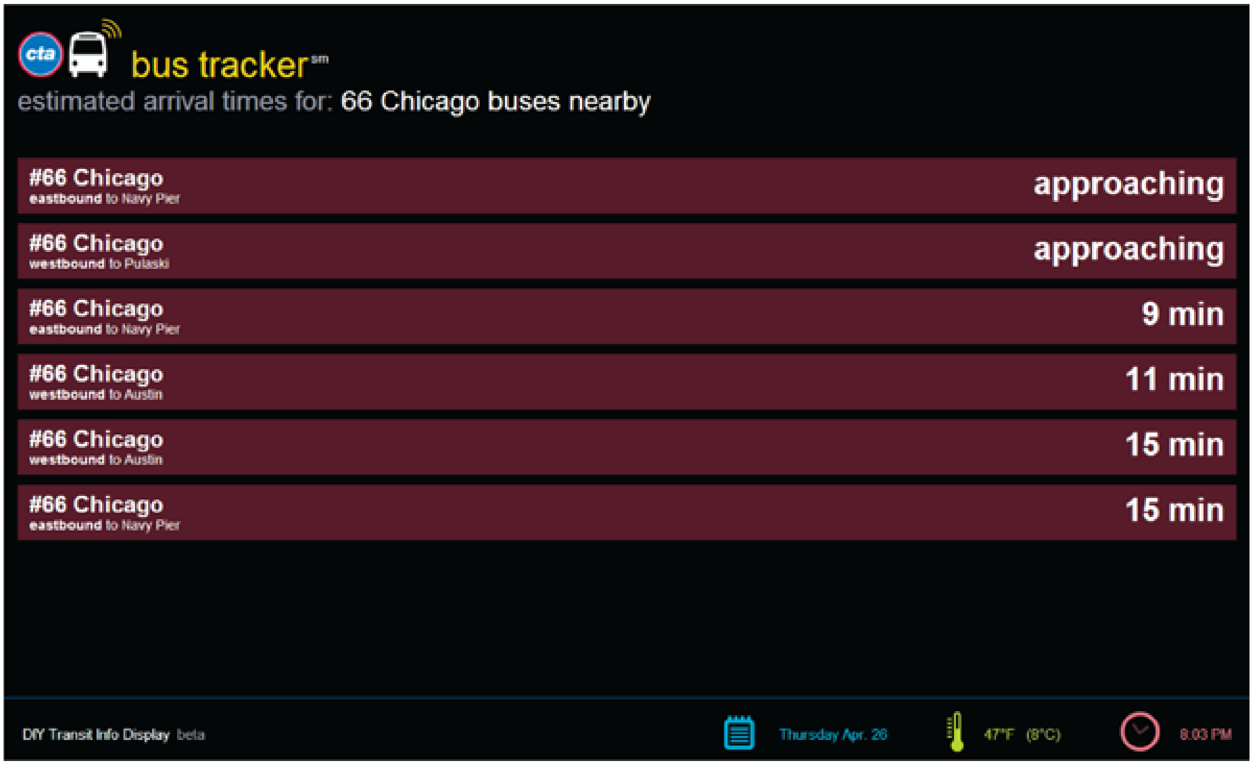

FIGURE 58 Sample DIY Bus TrackerSM display (*49*).

Management, also called Transportation Demand Management or TDM. TDM is about making individuals aware of their transportation options, including: route, time of travel and mode. In the broadest sense, TDM is defined as providing travelers with effective choices to improve travel efficiency and reliability" (*50*).

The Java Shack coffee shop near Court House in Arlington, Virginia, and the Red Palace bar on H Street in Washington, D.C., have "digital screens showing real-time transit arrivals and Capital Bikeshare availability. At Java Shack, customers can see the next [Washington Metropolitan Area Transit Authority (WMATA)] Metrobus, [Arlington Transit] ART, or [WMATA] Orange Line arrivals, and bike availability at the Capital Bikeshare [CaBi] station across the street. The Red Palace screen faces outward onto the sidewalk on H Street, letting passersby see their bus and CaBi options" (*51*).

Mobility Lab developed these screens to display local rail, bus, and bikeshare information. The overall goal for developing these screens was to help the individual make a trip from point A to point B in the Washington, D.C., area by providing real-time information presented in a readable manner. These are the first two screens deployed by Mobility Lab. As of April 2012, the screens have been operational for 3 months. Figures 59 and 60 show these screens.

> Every 20 seconds, our web server queries each transit agency for the arrival predictions for the stops near both test sites, then relays the data to the screens. The actual unit inside the shops is just a low-cost, barebones Linux system connected to a standard computer monitor and the business's own Wi-Fi and power. We've configured the box to automatically load up the screen when it starts, so there's no need to log in or launch an app after the unit is plugged in. (*50*)

Mobility Lab reported that after installing the signs, customers of these establishments have provided positive feedback. The signs are still relatively new as of the writing of this report, so no formal survey results are available. Rather than customers having to look at their smartphones, customers can simply look at the signs to find out their options for public transportation in the area.

Open data provided by the participating agencies has prompted the development of these signs. Each set of open data is in the GTFS-real-time format, so any person or entity that can develop an application based on open transportation data can install signs and provide real-time information anywhere real-time open data are available. For example, Mobility Lab worked closely with Capital Bikeshare, which is the only open data bikeshare system in the United States. (London provided open bikeshare data before Capital Bikeshare.)

Each screen's layout is customized. A designer helped make the displays visually-appealing and readable. For example, ART's real-time information is in green, WMATA buses are in blue, and the DC Circulator is in red. Display modification is easy and can be done from a central location. Further, a sign can run indefinitely until there is a significant

FIGURE 59 Multi-agency display located at Java Shack (*52*).

FIGURE 60 Mobility lab screen located at Red Palace Bar (*52*).

change in the information being displayed (e.g., adding a new agency or station).

Another key point to the success of these displays is that a display is affordable. Each screen is under $500, making it appealing to establishments such as the coffee shop and bar. Mobility Lab feels that more locations will want to purchase them because of the low price. Typical DMS pricing can range from $5,000 to $20,000 per unit (depending on a variety of factors), so under $500 is much more affordable than what many transit agencies pay to deploy DMS. Also, because of the low price, Mobility Lab has been approached by apartment buildings, colleges, and businesses. All of these establishments have enough motivation to pay to cover the costs because the displays could attract people to their businesses.

From a technical perspective, the communication technology used to provide information to the sign can be either wireless (as in the coffee shop) or a telephone line. The quality of the information is based upon the speed with which the information can be updated. Some agencies that provide open data limit the number of times you can access the data (e.g., every 20 seconds).

Beside the positive feedback from establishments and their customers, Mobility Lab is aware that the agencies participating by providing their data are realizing some benefits. For example, Capital Bikeshare has indicated that having this real-time information being displayed is serving its internal needs better. Application developers outside the agency are helping Capital Bikeshare realign its internal programs.

Although no formal surveys have been conducted to date to measure the success of these first two displays, they have been publicized heavily and the anecdotal feedback has been positive. Further, there is definitely a demand for such an affordable DMS. Mobility Lab wants to keep the displays useful and affordable. By maintaining its role as an integrator, it believes that it can accomplish these goals. Further, because it believes that introducing advertising on the displays might degrade the utility and increase the price, Mobility Lab is not considering adding advertising to the displays.

Finally, it believes that it can meet the goal to get people out of their cars by providing real-time transit and bikeshare options in an easy-to-read format.

Given that many younger people are less interested in buying automobiles, the displays may be appealing to those who seek alternative transportation options. For example, as of April 2012, Logan Circle in Washington, D.C. (which is close to Mobility Labs) has the lowest automobile ownership in the D.C. area.

Logan Circle residents own more bikes than they do cars. The young, single and hip neighborhood is leading the way to a car-free future, according to a new survey done by the National Capital Region Transportation Planning Board. Residents of Logan Circle, where 60 percent of the population is between the ages of 20 and 40 and 57 percent of households don't have land-line telephones, choose to walk for 56 percent of the trips they make in a day, much higher than the regional average of 9 percent. And with 6 percent of trips made by bike, the neighborhood had 10 times the number of bike trips than the regional average. (*52*)

CHAPTER SEVEN

FINDINGS, LESSONS LEARNED, AND CONCLUSIONS

SUMMARY OF PROJECT SCOPE

The primary purpose of this Synthesis was to determine the transit experience with electronic passenger information signage, and how agencies are using this dissemination channel to serve the needs of their customers. Thus, the project examined and documented the state of the practice in the use of electronic signage using the following five elements:

1. The underlying technology that is required to generate the information that will be disseminated on the signage. This element covers the required underlying software, hardware and communications.

2. The signage technology, including type of display (e.g., LED, LCD) and other characteristics such as what can be displayed using specific display types (e.g., characters only, characters and pictures).

3. The characteristics of the information displayed on the signage, including message types, content, format, and accessibility; the use of standards; and the reliability and accuracy of the displayed information.

4. The resources required to successfully deploy and manage electronic signage, including capital and operations and maintenance costs, and agency staff requirements.

5. The decision process that is used to (1) determine if signage will be deployed; (2) where the signage will be located; and (3) what will be displayed on the signage, as well as the contribution of electronic signage at stops and stations to an overall agency communications strategy, including "information equity." Here, information equity is defined as providing real-time information through at least two dissemination media, and in both audio and visual formats.

The project was conducted in the following four major steps:

- Literature review,
- Survey to collect information on a variety of factors,
- Analysis of survey results, and
- Interviews conducted with key personnel at agencies that have experience with deploying electronic signage.

This section of the report contains the project's findings, lessons learned, and conclusions.

PROJECT FINDINGS

Before summarizing the results of the Synthesis, two key statistics from the study are as follows:

- The number of signs reported by the respondents are shown in Table 27; and
- Almost 90% of respondents said that they plan to deploy additional electronic signs in the future, as shown in Figure 61.

TABLE 27
NUMBER OF ELECTRONIC SIGNS REPORTED BY SURVEY RESPONDENTS

Sign Type	Number of Signs Reported
Outdoor LED Signs	5,619
Indoor LED Signs	3,160
Outdoor LCD Signs	829
Indoor LCD Signs	512
Indoor Other	55
Outdoor Other	10

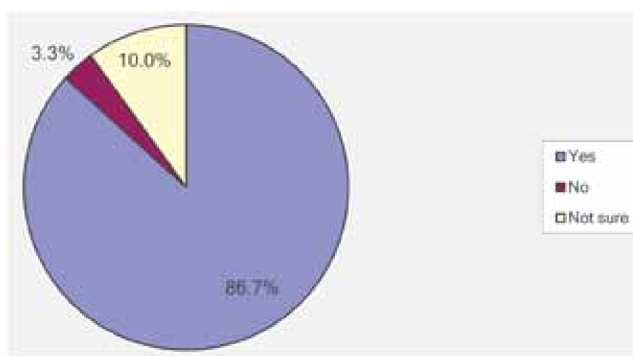

FIGURE 61 Percentage of respondents that plan to deploy more electronic signs in the future.

Key Findings

Based on the literature review, the responses to the questionnaire, and the case examples, this Synthesis project has four key findings. First, electronic signage is a viable and important dissemination media. Electronic signage meets goals that cannot necessarily be met by other dissemination media, such as mobile devices. For example, real-time information can be displayed on a sign when a mobile communication network is not available (e.g., in a subway environment, where full cellular coverage may not be available).

As shown in the survey results, almost all of the respondents deployed signage to increase customer satisfaction. Although many of these agencies are providing the same information through other channels [e.g., Internet, mobile devices, open data, interactive voice response (IVR), short message service (SMS) and subscription alerts], signage is still thought to have advantages over other media. These benefits include the following:

- Providing information that is easy to access once a trip has started;
- Providing information to those customers (and potential customers) who do not have mobile devices or alternate means to obtain the information;
- Reducing the perception of wait time;
- Improving the perception of the transit service being provided; and
- Increasing the feeling of safety and security.

Also, well over half of the respondents view electronic signage as a way to "keep up with technology" and show that they are progressive agencies. Further, just less than half of the respondents see signage as a way to increase ridership.

Second, there are several approaches to presenting transit information on electronic signage. Beyond the basic real-time information, which typically consists of displaying the route number, destination and the number of minutes until the vehicle arrives at the station/stop, disruption information can be displayed in a variety of different ways. The content and format of disruption messages are dependent upon the type and size of the sign, and the type of disruption. For example, Network Rail (United Kingdom) provides guidance on the content of messages depending on whether the disruption is infrastructure-related; a major and external incident; or related to train crew resources, train failures, or industrial action. Further, guiding principles related to messaging and the impacts on the customer are covered in Network Rail's Operational Information System Process Guide. The results of the Synthesis show that there is not a singular approach to determining message content, but rather a number of factors that must be considered.

Third, the results of the literature review and survey indicates that the capital cost of signage is fairly high, but the cost of newer, customizable electronic signs is lower. The survey results in Table 28 show that the capital cost of signs vary widely.

TABLE 28
CAPITAL COSTS

Sign Type	Number of Respondents	Cost Range (per sign)
Indoor LED	5	$200 to $12,500
Outdoor LED	18	$1,500 to $17,000
Indoor LCD	6	$500 to $5,000
Outdoor LCD	4	$1,500 to $10,000

A result of the Mobility Lab case example was that their indoor LCD, customizable signs (using open data) run around $500 or less per unit, making it affordable for many businesses. Also, given the ease with which they can be modified and maintained, these types of signs have a lot of potential for deployment over the more traditional LED signage. The cost of the underlying technology has to be taken into consideration, but if open data are used to provide the information displayed on the sign, the cost may be lower (down to the cost of "cleaning" the open data and the communication technology to send the information to the sign). Another factor relating to lower costs for these types of signs is that if they are located inside an establishment, they do not have to be "hardened," which they would need to be if placed outside or in a transit station environment. Further, existing network connections within the establishment where the sign is located may contribute to the lower cost.

Finally, newer sign technology, such as LCD signs, is capable of greatly expanding the volume and depth of the information being provided. First, electronic signs can be interactive as shown in the examples from New York MTA/New York City Transit and Brussels, Belgium. Second, more disruption information, including alternatives, can be provided since there is much more real estate on the sign to display this information. In the case of the NY MTA/NYCT On the Go! Travel Stations, the 47-inch touchscreens provide subway alerts/notifications, trip planning, subway map, service status, elevator status, information about key destinations, and planned construction, with advertising at the bottom of the screen. As stated in the U.K. case example, the ability to provide more information on these kinds of displays is revolutionizing the impact on customers.

Findings Based on Five Elements

Specific findings based on the aforementioned elements are as follows. First, as expected, the top two underlying technologies are computer-aided dispatch (CAD)/automatic vehicle location (AVL) and real-time prediction software that are purchased as part of a CAD/AVL or related system. Among the respondents, 87% of the signs are LED. This is because until recently, LED signs were the most applicable in the outside environment. The top type of information provided on electronic signs is next vehicle arrival/departure prediction time. In terms of sign location, most are located either in a transit station, or at a bus or bus rapid transit stop.

The characteristics of the signs (e.g., dimensions, number of characters displayed, number lines on the display, colors used) vary greatly depending on the sign type.

Second, the overwhelming reason for deploying electronic signage is to increase customer satisfaction, followed by to supplement other methods of disseminating information. Forty percent of the respondents performed a study to determine whether or not to deploy electronic signage, and of those, the majority conducted a business case analysis. The most prevalent criteria for locating signage was board counts at stops/stations, followed by the availability of power and the number of lines or routes at a station or stop.

Third, the format of the information displayed on a sign varied depending on the type of information and the sign's characteristics (e.g., type, number of characters available). More than 95% of respondents used the Americans with Disabilities Act Accessibility Guidelines' mounting location and height, and just over the 90% used the character height guidance to determine the mounting and display characteristics of the electronic signs. 89% of respondents provide information displayed on a sign in audio format. A variety of standards are being used including the General Transit Feed Specification (GTFS), Transit Communications Interface Profiles (TCIP), Service Interface for Real Time Information (SIRI) and NextBus Public Extensible Markup Language (XML) Feed. In terms of accuracy and reliability, respondents used various methods to monitor these two characteristics.

Fourth, resource requirements for deploying electronic signage varied widely, and there was limited information regarding the actual labor required from specific staff in the organization.

In terms of sign costs, the capital costs varied significantly. Further, little information was reported on operations and maintenance costs. They varied from $0 to $1,000 on an annual basis per sign type.

Finally, in more than 80% of the respondents that have a communication strategy, electronic signage contributes to that strategy. Seventy percent of the respondents consider providing transit information on electronic signage as a way to attract "choice" riders. Just over 65% of the respondents consider information equity. Only one agency has electronic signs that display advertising—in this case, advertising takes precedence over what is displayed on the sign, so real-time information is displayed only when there is an available "slot" in between advertising.

LESSONS LEARNED

The four categories of lessons learned from the study are as follows:

- Ability to minimize capital and ongoing costs associated with the signage;
- Issues associated with ensuring the accuracy and validity of the underlying data, and monitoring what is displayed on the signs;
- Issues associated with the number of signs deployed and the placement of the signs; and
- Overall lessons learned that would benefit transit agencies that are considering deploying electronic signage.

The issues reported by the survey respondents related to minimizing the capital and ongoing costs are as follows:

- Use only one size sign.
- Invest in generic signs that you can interface to real-time information systems, rather than proprietary signs that can lock you in.
- Infrastructure costs such as getting electrical power to signs can often be far more significant than anticipated.
- Several respondents mentioned the expense associated with sign procurement, installation, and maintenance. One respondent said, "concentrate on electronic personal devices, not widespread physical display rollout."

In terms of ensuring the accuracy and validity of the underlying data, and monitoring what is displayed on the signs, many respondents discussed the importance of ensuring the accuracy of the underlying data (primarily predicted arrival times). One respondent said "bad information is worse than NO information." Another respondent mentioned that "customers started to use the signs immediately as they were installed, even before the installation crews put their tools away. They seemed to accept immediately that the information was valuable and correct." The timeliness of the displayed information was mentioned by one respondent. Another respondent mentioned the challenges associated with accurately predicting the time that a route will start as a result of driver changeovers and operational characteristics.

Another critical issue in monitoring the accuracy of what is displayed on the signage is having the capability to assess the "health" of the sign by collecting diagnostics in real-time, and being able to view what is being displayed on the sign at any given point in time. Several agencies mentioned that there is a need for two-way communication with signs so that displays can be monitored and corrective information can be sent to sign. Further, one respondent mentioned the importance of ensuring network connectivity. Finally, another respondent mentioned that any changes or upgrades to underlying systems could alter or affect the data feed to the sign, so this must be monitored as well.

Issues associated with the number of signs deployed and the placement of the signs cover several different lessons, as follows:

- Getting full buy-in from locations where signage will be located, especially if the signage is on private property.
- Cooperating with local authorities to find out which is the "best" place to locate signage.
- Determining the constant demand for more signs, especially if not all stations are equipped. There are not enough locations from the public's perception.
- Handling local zoning restrictions, and dealing with different city codes and permitting agencies.

The overall lessons learned that would benefit transit agencies that are considering deploying electronic signage are reported by the survey respondents as follows. These lessons, however, can be in conflict with each other because they were directly reported by survey respondents.

- Ensure proper operation after installation (i.e., testing).
- LED technology is reported to be much more reliable in hot, humid climates such as Florida.
- Make your screens as multimodal as possible.
- Keep the messages displayed on the signs simple.
- Do not try to serve multiple purposes (e.g., advertising, wayfinding) with the signage.
- Have the message satisfy everyone's needs.
- Branding has been a big issue because of the privatized nature of public transport industry in the United Kingdom.
- Coordinate audio and sign information.
- Sign mounting location takes into account all angles of the platform or bus shelter.
- Infrastructure requirements for power and communications are the biggest challenge.
- There are a low number of practical solar-powered options.
- Integrate new systems.
- Civil works affects the signage location.

CONCLUSIONS

Several conclusions can be drawn from the Synthesis. First, the deployment of electronic signage is to be considered as one of several methods to disseminate passenger information, rather the only method. The decision to deploy should be based on the expected impact of the signage on customers in terms of the benefits mentioned earlier in the report (e.g., reduced anxiety, more flexibility in making travel decisions), as well as the agency's interest in improving customer convenience. Providing signage at stops/stations can be much more convenient to customers than having to consult a mobile device, which may require input and keystrokes.

Second, there are opportunities to capitalize on agencies' open data and low-cost, customizable displays—perhaps creating a market for third-party providers to provide signage for a transit agency or a region with multiple transit agencies. This approach is analogous to the development of third-party applications on mobile devices to display real-time transit information. Further, being able to provide multimodal information in certain venues has the potential to provide more convenient and better information regarding all the travel options (and could eventually increase transit ridership). As reported in "Logan Circle Leads Way to Car-free Future," given that automobile ownership is down, particularly with young age groups (under 30), providing information on all travel options could have a significant impact on modal choice.

Third, there is potential to expand the typical information provided on passenger information displays by utilizing full-screen or large touchscreen displays such as those deployed at NY MTA/NYCT and in Belgium. However, these displays are interactive, meaning that the information provided on these displays will not necessarily be available to customers near the display. If someone is interacting with the display, others may not be able to see the display; also, even if they can view what is displayed, it may not be the information they are interested in. Further, this type of display is different from electronic signs that provide real-time arrival and disruption information, so the impact of this type of display will be different since customers will be interacting with it differently than they would with a more typical noninteractive display.

Fourth, while information displayed on electronic signage cannot be personalized, the content of messages is extremely important to convey specific types of events. For example, the study conducted to evaluate TfL's Countdown system (Countdown sign evaluation 08210) analyzed the information requirements and provision for three distinct service experiences: normal service/daily basis, minor delays, and severely disrupted service, and for service frequency from high-frequency to low-frequency service. Key findings of the evaluation were in two major categories: the decision-making process and information requirements. The summary of the findings regarding decision-making are as follows:

- "Decision-making process is very different across the spectrum of scenarios from simplistic (normal service) through to sophisticated (severely disrupted)"
- "Therefore information requirements differ across the spectrum"
- "And scenario type also alters expectations of how information is provided (e.g., the higher frequency, daily routine information provision feels very different to the infrequent, severely disrupted scenario)"
- "Simplicity of information provision is key. Taking the bus is considered a simple process and information provision needs to reflect and enhance that simplicity" (Countdown sign evaluation 08210, p. 14).

The evaluation included a detailed assessment of information requirements for each service experience and frequency.

Information was defined as being absolutely necessary through "nice to have" to answer three questions:

- What questions need answering?
- Current information provision?
- New information provision—what would they like?

The framework used for this evaluation could be applied to almost any agency in order to determine the content of messages displayed on electronic signage.

Finally, respondents mentioned that a plan for measuring and monitoring the accuracy, reliability and timeliness is an important element of deploying electronic signage. Of all the lessons learned reported by survey respondents, comments regarding monitoring were more plentiful than any other type of comment. A few agencies reported that they use only customer complaints to monitor the quality of the information displayed on the signage. As one respondent stated, "bad information is worse than NO information"—the quality of the information is critical to the success of signage being used and trusted by customers. Although the literature does not include any studies that assess the impact of "bad information" on signage, agencies should not be relying on customer complaints alone to determine the quality of the information being displayed.

The development and implementation of a proactive program that incorporates both automated and manual monitoring processes was considered to be the best approach. However, additional technologies may be required for most agencies to implement automated processes, because several CAD/AVL systems do not record the exact time that a vehicle arrives at a stop (unless it is a timepoint). Some advances may need to be made in order to automate a quality monitoring program.

Some CAD/AVL systems that include prediction software determine the accuracy of the predictions by comparing predicted times and actual times, so this part of the information quality monitoring could be more easily put in place. In one case, the prediction of minutes to arrival is compared with actual arrival time, which can be available from the AVL system. In this case, reports regarding prediction accuracy are available from both live and historic databases. Because signs usually are controlled centrally, these reports assess the accuracy of information on the signs (with a small lag time resulting from network latency). However, the system does not create "alarms" when prediction errors are higher than a certain threshold.

SUGGESTIONS FOR FUTURE STUDY

Based on the survey results and literature review, the following six areas are suggested for future study to help agencies determine whether and how they should deploy electronic signage.

First, one element that is not well understood in deploying electronic signage is the amount of staff time that is required for successful implementation and ongoing operations and maintenance. This will vary by the type of signage and its environment, but a study that examines just how much time is required by various departments and staff is important. Further, a discussion of the costs associated with operations and maintenance for each type of sign and specific environment (e.g., subway station platform) will be helpful.

Second, agencies would benefit from a "model" to determine the "business case" for deploying electronic signage would be helpful. Such a model would help an agency select the most appropriate sign technology and location, taking into account the types of information displayed on the signage and the resources required for sign type and location, in addition to factors such as the overall goals of the agency in improving customer convenience, attracting new riders and/or maintaining existing ridership, and other factors. From a customer information strategy perspective, this model should incorporate other dissemination media into the assessment. For example, if real-time information is being provided through mobile devices, an agency may want to deploy a lower number of signs than if information was not provided on mobile devices.

Third, more guidance is needed for providing an audio version of an electronic sign display. To date, agencies have used a variety of methods, including providing a button that can be pressed to "read" what is displayed on the sign and having an announcement of what is displayed on the sign at a specific frequency (e.g., every 3 min).

Fourth, more in-depth information regarding how to determine the content of messages displayed on electronic signage could be made available to agencies. This could be in the form of a guidance document similar to the one produced by Network Rail (*Operational Information System (OIS): Process Guide*) that provides information on how various types of messages should be conveyed and examples of how specific messages are constructed.

Fifth, more guidance is needed to address accessibility issues such as best practices in providing information displayed on signage in audio format. Transit agencies have employed several approaches, as described in the survey results, but more information is needed to ensure compliance with regulations.

Finally, more information is needed to explore other ways of providing power to electronic signs, such as solar power. Several vendors offer solar, pole-mounted electronic signs, but they have not been widely discussed in the literature or deployed by the survey respondents. Key data, such as operations and maintenance costs, will assist agencies in determining whether or not this sign technology is applicable to their situation.

LIST OF ABBREVIATIONS AND ACRONYMS

ADAAG	Americans with Disabilities Act Accessibility Guidelines
AMT	Agence métropolitaine de transport
APTMS	Advanced Public Transport Management System
AVL	Automated vehicle location
BART	Bay Area Rapid Transit
BRT	Bus Rapid Transit
CAD	Computer-aided Dispatch
CARTA	Chattanooga Area Regional Transportation Authority
CCTV	Closed-circuit television
CFR	Code of Federal Regulations
CMS	Changeable Message Sign
CTA	Chicago Transit Authority
DMS	Dynamic message sign
EPD	Electronic paper display
GB	Great Britain
GPS	Global Positioning System
GTFS	General Transit Feed Specification
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
IT	Information technology
ITS	Intelligent Transportation Systems
ITSA	Intelligent Transportation Society of America
IVR	Interactive Voice Response
JSON	JavaScript Object Notation
KCATA	Kansas City Area Transportation Authority
LA	Local authority

LCD	Liquid crystal display
LED	Light-emitting diode
LIRR	Long Island Rail Road
MAAB	Massachusetts Architectural Access Board
MassDOT	Massachusetts Department of Transportation
MBTA	Massachusetts Bay Transportation Authority
MDT	Mobile data terminal
MTA	Metropolitan Transportation Authority (New York City)
NYCT	New York City Transit
NTCIP	National Transportation Communications for ITS Protocol
OIS	Operational Information System
OS	Operating systems
PID	Passenger Information Display
RATP	Régie Autonome des Transports Parisiens
REST	Representational State Transfer
RFID	Radio Frequency Identification
RIAS	Remote Infrared Audible Signage
RTC	Regional Transportation Commission of Washoe County
RTIG	Real Time Information Group
RTPI	Real-time Passenger Information
RTTI	Real Time Traffic and Travel Information
SCADA	Supervisory Control and Data Acquisition
SIRI	Service Interface for Real Time Information
SMS	Short Message Service
SNCB	National Railway Company of Belgium
SOAP	Simple Object Access Protocol
STAR	Service des Transport en commun de l’Agglomération Rennaise
STL	Société de transport de Laval

TCIP	Transit Communications Interface Profiles
TfL	Transport for London
TFT	Thin film transistor
TOC	Train operating companies
TriMet	Tri-County Metropolitan Transportation District of Oregon
TRIS	Transportation Research Information Services
TxC	TransXChange
U.K.	United Kingdom
WAP	Wireless Application Protocol
WMATA	Washington Metropolitan Area Transit Authority
XML	Extensible Markup Language

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APPENDIX A

Survey Questionnaire

Use of Electronic Passenger Information Signage in Transit

1. Survey Topic Question

Transit agencies are deploying electronic signage to display passenger information. There are several components of deploying this signage that include not only the underlying technology (e.g., automatic vehicle location) needed to generate the information that is displayed on the signage, and characteristics of the signage, but also the types, content and format of the displayed information, the decision process governing sign deployment, and how deploying this signage contributes to an overall customer information strategy. This survey focuses on collecting information about the use of electronic signage at stops and stations. Once the survey results are reviewed, key agencies that are using electronic signage will be selected for telephone interviews to gather more in-depth information. All survey responses will be confidential. The final results of the survey will be synthesized into a report that will be published by the Transportation Research Board (TRB). Thank you for taking the time to complete this survey!

***1. Has your agency deployed electronic signage to provide information to your customers at stops or stations?**

- ○ Yes
- ○ No

Use of Electronic Passenger Information Signage in Transit

2. Electronic Signage Still Turned On?

1. Is the electronic signage still turned on?

- ◯ Yes
- ◯ No

Use of Electronic Passenger Information Signage in Transit

3. Considered Electronic Signage?

1. Has your agency considered electronic signage if you currently do not have electronic signage?

- ◯ Yes
- ◯ No

Use of Electronic Passenger Information Signage in Transit

4. More Initial Questions About Electronic Signage

1. Why not? Please check all that apply.

- [ ] Too costly to operate
- [ ] Funding not available to continue to operate
- [ ] Unresolved technical issues
- [ ] Unresolved issues regarding the accuracy of information displayed on the signs

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

5. Reason for Rejecting Electronic Signage

1. Why did you reject the idea of deploying electronic signage? Please check all that apply.

- [ ] Capital cost too high
- [ ] Operations and maintenance cost too high
- [ ] Could not obtain funding
- [ ] Lack of underlying technology (e.g., automatic vehicle location)
- [ ] Lack of technical expertise

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

6. Respondent Information

1. Date of your reponse

	MM		DD		YYYY
Month/Day/Year		/		/	

*2. Survey Contact Information

Name and Title:

Transit Agency/Organization:

Address 1:

Address 2:

City/Town:

State/Province:

ZIP/Postal Code:

Country:

Email Address:

Phone Number:

Use of Electronic Passenger Information Signage in Transit

7. Transit System Characteristics

1. Which modes does your agency either directly operate or operate using a contractor?

- [ ] Fixed-route bus
- [ ] Paratransit
- [ ] Heavy rail/subway
- [ ] Light rail/streetcar
- [ ] Bus rapid transit
- [ ] Commuter rail
- [ ] Ferry

Other (please specify)

2. How many riders do you carry on each mode on an annual basis?

Fixed-route bus

Paratransit

Heavy rail/subway

Light rail/streetcar

Bus rapid transit

Commuter rail

Ferry

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

3. What motivated your agency to deploy electronic signs? Please check all that apply.

- ☐ Increase ridership
- ☐ Increase customer satisfaction
- ☐ Customers requested the signs
- ☐ Improve perception of transit system
- ☐ Influenced by other agencies' deployment of signage
- ☐ Received funding to deploy signage
- ☐ Part of a subway, light rail/streetcar or BRT project
- ☐ Because we are a progressive agency
- ☐ We want to keep up with current technology
- ☐ To supplement other methods of disseminating information

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

8. Underlying Technology to Generate Information Displayed on Electronic Signa...

1. What underlying software, hardware and communications systems do you utilize to generate and disseminate information on electronic signs at stops or stations? Please check all that apply.

- [ ] Vehicle tracking: Computer-aided dispatch (CAD)/ automatic vehicle location (AVL)
- [ ] Vehicle tracking: Global positioning system (GPS)
- [ ] Vehicle tracking: Rail signal system
- [ ] Sign communication: Hard-wired communication (e.g., Ethernet)
- [ ] Sign communication: Wireless area network (e.g., wireless Ethernet)
- [ ] Sign communication: Agency radio network
- [ ] Sign communication: Cellular radio network
- [ ] Real-time predicition software: Developed in-house
- [ ] Real-time predicition software: Open source
- [ ] Real-time predicition software: Purchased independently
- [ ] Real-time predicition software: Purchased as part of a CAD/AVL or related system
- [ ] Real-time predicition software: Licensed (software-as-a-service)

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

9. Electronic Sign Characteristics

1. What type of electronic signs (a.k.a dynamic message signs, variable message signs or changeable message signs) has your agency deployed? Please check all that apply.

	Indoors	Outdoors
Light-emitting diode (LED)	☐	☐
Liquid crystal display (LCD)	☐	☐

Other (please specify and indicate if located indoors or outdoors)

2. How many of each type of electronic signs has your agency deployed?

Indoor LED signs

Outdoor LED signs

Indoor LCD signs

Outdoor LCD signs

Indoor Other (please specify)

Outdoor Other (please specify)

3. Where are electronic signs located?

	Inside transit station (e.g., on subway platform, at faregates)	Outside transit station	Inside non-transit location	Outside non-transit location	At bus/BRT stops with shelter	At bus/BRT stops without shelter	At end of line/route terminal	At transfer stop
Indoor LED	☐	☐	☐	☐	☐	☐	☐	☐
Outdoor LED	☐	☐	☐	☐	☐	☐	☐	☐
Indoor LCD	☐	☐	☐	☐	☐	☐	☐	☐
Outdoor LCD	☐	☐	☐	☐	☐	☐	☐	☐
Indoor Other	☐	☐	☐	☐	☐	☐	☐	☐
Outdoor Other	☐	☐	☐	☐	☐	☐	☐	☐

Use of Electronic Passenger Information Signage in Transit

4. What is the range of dimensions (in inches) of each type of electronic sign your agency has deployed? Please specify the width, length and depth. For example, if you have multiple types of indoor LED signs, the range of dimensions might be 12W x 48L x 12D to 24W x 60L x 12D.

Indoor LED

Outdoor LED

Indoor LCD

Outdoor LCD

Indoor Other

Outdoor Other

5. How many lines of text are available on each type of electronic sign your agency has deployed? If you have more than one of a specific type of sign, please indicate the number of lines of text for each sign. For example, if you have two indoor LED signs, and one has 4 lines of text and the other has 6 lines of text, your response would be 4, 6.

Indoor LED

Outdoor LED

Indoor LCD

Outdoor LCD

Indoor Other

Outdoor Other

6. How many characters per line of text are available on each type of electronic sign your agency has deployed? If you have more than one of a specific type of sign, please indicate the number of characters per line of text for each sign. For example, if you have two indoor LED signs, and one has 24 characters per line and the other has 36, your response would be 24, 36.

Indoor LED

Outdoor LED

Indoor LCD

Outdoor LCD

Indoor Other

Outdoor Other

Use of Electronic Passenger Information Signage in Transit

7. What is the character height (in inches) of the text displayed on each type of electronic sign your agency has deployed? If you have more than one of a specific type of sign, please indicate the character height for each sign. For example, if you have two indoor LED signs, and one has a character height of 3 and the is 4, your response would be 3, 4.

Indoor LED

Outdoor LED

Indoor LCD

Outdoor LCD

Indoor Other

Outdoor Other

8. What text color(s) do you use on each type of electronic sign your agency has deployed?

Indoor LED

Outdoor LED

Indoor LCD

Outdoor LCD

Indoor Other

Outdoor Other

9. Can your electronic signs display text, graphics or video? Please check all that apply.

	Text	Graphics	Video
Indoor LED	☐	☐	☐
Outdoor LED	☐	☐	☐
Indoor LCD	☐	☐	☐
Outdoor LCD	☐	☐	☐
Indoor Other	☐	☐	☐
Outdoor Other	☐	☐	☐

Other (please specify)

10. Are multiple languages supported on your electronic signage?

- ○ Yes
- ○ No
- ○ Not sure

Use of Electronic Passenger Information Signage in Transit

10. More Electronic Sign Characteristics

1. If Yes, are they multi-lingual for some or all information?

- ◯ Some information can be presented multi-lingual
- ◯ All information can be presented multi-lingual
- ◯ Not sure

2. What communication technology is used for each sign type to receive messages? Please check all that apply.

	RS-232	RS-422	Ethernet - wired	Ethernet - fiber	Radio	Cellular	Other
Indoor LED	☐	☐	☐	☐	☐	☐	☐
Outdoor LED	☐	☐	☐	☐	☐	☐	☐
Indoor LCD	☐	☐	☐	☐	☐	☐	☐
Outdoor LCD	☐	☐	☐	☐	☐	☐	☐
Indoor Other	☐	☐	☐	☐	☐	☐	☐
Outdoor Other	☐	☐	☐	☐	☐	☐	☐

Other (please specify)

3. Does the signage have internal diagnostics and is capable of sending information to a central location (e.g., sign "health")? Please check all that apply.

	Internal diagnostics	Can send information	Other
Indoor LED	☐	☐	☐
Outdoor LED	☐	☐	☐
Indoor LCD	☐	☐	☐
Outdoor LCD	☐	☐	☐
Indoor Other	☐	☐	☐
Outdoor Other	☐	☐	☐

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

4. How is power provided for the signage?

	Direct power from power grid at sign location	Direct power from other source at sign location	Solar power	Other
Indoor LED	☐	☐	☐	☐
Outdoor LED	☐	☐	☐	☐
Indoor LCD	☐	☐	☐	☐
Outdoor LCD	☐	☐	☐	☐
Indoor Other	☐	☐	☐	☐
Outdoor Other	☐	☐	☐	☐

Other (please specify)

5. Is the information displayed on the signage available in audio format?

	Yes	No
Indoor LED	☐	☐
Outdoor LED	☐	☐
Indoor LCD	☐	☐
Outdoor LCD	☐	☐
Indoor Other	☐	☐
Outdoor Other	☐	☐

Other (please specify)

6. If the information displayed on the signage is available in audio format, how is the audio provided?

	Pushbutton-activated audio	Sign periodically announces what is displayed on the sign	User/passenger device (e.g., Talking Signs)	Other
Indoor LED	☐	☐	☐	☐
Outdoor LED	☐	☐	☐	☐
Indoor LCD	☐	☐	☐	☐
Outdoor LCD	☐	☐	☐	☐
Indoor Other	☐	☐	☐	☐
Outdoor Other	☐	☐	☐	☐

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

7. If the information displayed on the signage is announced periodically, at what frequency is it announced? For example, once every three minutes.

Indoor LED	
Outdoor LED	
Indoor LCD	
Outdoor LCD	
Indoor Other	
Outdoor Other	

8. Is your agency aware of the Americans with Disabilities Act Accessiibility Guidelines (ADAAG) regarding signage (e.g., requirements for mounting height based on horizontal viewing distance and character height)?

- ◯ Yes
- ◯ No

Use of Electronic Passenger Information Signage in Transit

11. Use of Americans with Disabilities Act Accessibility Guidelines (ADAAG)

1. If Yes, please specify which ADAAG requirements you used to determine the mounting and display characteristics of the electronic signs.

- [ ] Character Proportion
- [ ] Character Height
- [ ] Finish and Contrast
- [ ] Mounting Location and Height
- [ ] Illumination Levels

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

12. Characteristics of the Information Displayed on Electronic Signage

1. Please note the type of transit information your agency provides on electronic signage. Please check all that apply.

- [ ] Next vehicle arrival/departure prediction time
- [ ] Real-time vehicle location
- [ ] Availability of information and dissemination media
- [ ] Identification of service of disruptions
- [ ] Information on planned detours
- [ ] Schedule information during special events (e.g., Boston Marathon)
- [ ] Emergency information (e.g., evacuation due to fire)
- [ ] Vehicles/routes available for transfer
- [ ] Real-time information on availability of elevators and escalators
- [ ] Number of cars on the next train
- [ ] Wi-Fi access points and real-time information on availability
- [ ] Parking availability
- [ ] Station map
- [ ] Map of area around stop/station
- [ ] Public service announcements
- [ ] Advertising

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

2. Please note how often the information displayed on electronic signage is updated? Please check all that apply.

	Update on an on-going basis	Update per defined threshold (e.g., every two minutes)	Update manually	Update when underlying information is not available to display (e.g., arrival time prediction not available)
Next vehicle arrival/departure prediction time	☐	☐	☐	☐
Real-time vehicle location	☐	☐	☐	☐
Availability of information and dissemination media	☐	☐	☐	☐
Identification of service of disruptions	☐	☐	☐	☐
Information on planned detours	☐	☐	☐	☐
Schedule information during special events (e.g., Boston Marathon)	☐	☐	☐	☐
Emergency information (e.g., evacuation due to fire)	☐	☐	☐	☐
Vehicles/routes available for transfer	☐	☐	☐	☐
Real-time information on availability of elevators and escalators	☐	☐	☐	☐
Number of cars on the next train	☐	☐	☐	☐
Wi-Fi access points and real-time information on availability	☐	☐	☐	☐
Parking availability	☐	☐	☐	☐
Station map	☐	☐	☐	☐
Map of area around stop/station	☐	☐	☐	☐
Public service announcements	☐	☐	☐	☐
Advertising	☐	☐	☐	☐

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

3. Is the information provided on electronic signage also provided on other media?

	Internet accessed by personal computer	Mobile web/internet	Data feed for independent developers	Interactive voice response (IVR)	Smartphone applications	Two-way text messaging (SMS)	Subscription alerts	Other
Next vehicle arrival/departure prediction time	☐	☐	☐	☐	☐	☐	☐	☐
Real-time vehicle location	☐	☐	☐	☐	☐	☐	☐	☐
Availability of information and dissemination media	☐	☐	☐	☐	☐	☐	☐	☐
Identification of service of disruptions	☐	☐	☐	☐	☐	☐	☐	☐
Information on planned detours	☐	☐	☐	☐	☐	☐	☐	☐
Schedule information during special events (e.g., Boston Marathon)	☐	☐	☐	☐	☐	☐	☐	☐
Emergency information (e.g., evacuation due to fire)	☐	☐	☐	☐	☐	☐	☐	☐
Vehicles/routes available for transfer	☐	☐	☐	☐	☐	☐	☐	☐
Real-time information on availability of elevators and escalators	☐	☐	☐	☐	☐	☐	☐	☐
Number of cars on the next train	☐	☐	☐	☐	☐	☐	☐	☐
Wi-Fi access points and real-time information on availability	☐	☐	☐	☐	☐	☐	☐	☐
Parking availability	☐	☐	☐	☐	☐	☐	☐	☐
Station map	☐	☐	☐	☐	☐	☐	☐	☐
Map of area around stop/station	☐	☐	☐	☐	☐	☐	☐	☐
Public service announcements	☐	☐	☐	☐	☐	☐	☐	☐
Advertising	☐	☐	☐	☐	☐	☐	☐	☐

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

4. Please provide the format of each type of message displayed on electronic signage. For example, "Line/No. Cars/Destination/Minutes" or "Route/Destination/Arrival Time" If possible, please email photos of the content on your signage.

a.

b.

c.

d.

e.

f.

g.

5. What data exchange standards are your agency using to provide transit information on electronic signage? Please check all that apply.

- ☐ Service Interface for Real Time Information (SIRI)
- ☐ General Transit Feed Specification (GTFS)
- ☐ GTFS-realtime
- ☐ NextBus Public XML Feed
- ☐ Clever Devices API
- ☐ Transit Communications Interface Profiles (TCIP)
- ☐ Standard Object Access Protocol (SOAP)
- ☐ Representational State Transfer (REST)
- ☐ Java script Object Notation (JSON)

Other (please specify)

6. How does your agency ensure the accuracy and reliability of the information provided via electronic signs?

Use of Electronic Passenger Information Signage in Transit

7. Please indicate if and how your agency measures the following?

Time that real-time information system is operational as a percent of total transit operating time (please indicate percentage)

Accuracy (e.g., +- 1 minute within 5 minutes to arrival, +-2 minutes within 5-10 minutes to arrival, +- 5 minutes beyond 20 minutes to arrival)

Reliability-system is operating within the above accuracy standards a certain percent of the time (please indicate percentage)

8. What text is displayed on the signage as a vehicle arrives, boards and departs?

9. What text is displayed on the signage in the event of service disruptions, and how is it generated (e.g., automatically or manually via dispatch)?

10. What is displayed on the signage when real-time information is not available (e.g., real-time arrival predictions are not being made)?

Use of Electronic Passenger Information Signage in Transit

13. Required Resources

1. What is the per unit capital cost (in U.S. dollars) of each type of sign? You do not need to enter a dollar sign. If you have more than one of a specific type of sign, please provide the per unit capital cost for each sign separated by commas. For example, if you have two indoor LED signs, and one cost $1,000 per unit and the other cost $5,000 per unit, your response would be 1000, 5000.

Indoor LED

Outdoor LED

Indoor LCD

Outdoor LCD

Indoor Other

Outdoor Other

2. What is the per unit annual operating and maintenance cost (in U.S. dollars) of each type of sign? You do not need to enter a dollar sign.

Indoor LED

Outdoor LED

Indoor LCD

Outdoor LCD

Indoor Other

Outdoor Other

3. What is the per unit monthly communication cost (in U.S. dollars) for each type of sign? You do not need to enter a dollar sign.

Indoor LED

Outdoor LED

Indoor LCD

Outdoor LCD

Indoor Other

Outdoor Other

Use of Electronic Passenger Information Signage in Transit

4. What is the per unit monthly power cost (in U.S. dollars) for each type of sign? You do not need to enter a dollar sign.

Indoor LED	
Outdoor LED	
Indoor LCD	
Outdoor LCD	
Indoor Other	
Outdoor Other	

5. Which departments lead specific aspects of electronic signage implementation?

	Information technology	Operations	Training	Marketing/Communications	Human resources	Planning	Maintenance	Procurement/Legal	Customer Service
Planning for the signage	☐	☐	☐	☐	☐	☐	☐	☐	☐
Developing requirements/specifications of the signage	☐	☐	☐	☐	☐	☐	☐	☐	☐
Procuring the signage	☐	☐	☐	☐	☐	☐	☐	☐	☐
Installing the signage	☐	☐	☐	☐	☐	☐	☐	☐	☐
Operating the signage	☐	☐	☐	☐	☐	☐	☐	☐	☐
Placing messages on the signage	☐	☐	☐	☐	☐	☐	☐	☐	☐
Maintaining the signage	☐	☐	☐	☐	☐	☐	☐	☐	☐
Responding to customer complaints about accuracy of information	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐	☐	☐	☐	☐

Other (please specify)

Use of Electronic Passenger Information Signage in Transit

6. What are the training requirements for each department/staff who are responsible for operating and maintaining electronic signage? Please indicate the requirements in number of labor hours per month.

Information technology	
Operations	
Training	
Marketing/communications	
Human resources	
Planning	
Maintenance	
Procurement/legal	
Customer service	
Other	

7. How many labor hours are spent by each department/staff who are responsible for operating and maintaining electronic signage? Please indicate the requirements in number of labor hours per month.

Information technology	
Operations	
Training	
Marketing/communications	
Human resources	
Planning	
Maintenance	
Procurement/legal	
Customer service	
Other	

Use of Electronic Passenger Information Signage in Transit

14. Decision Process to Deploy Electronic Signage

1. Did your agency conduct a study to determine whether or not to deploy electronic signage to display transit information?

- ◯ Yes
- ◯ No
- ◯ Not sure

Use of Electronic Passenger Information Signage in Transit

15. More About the Decision Process to Deploy Electronic Signage

1. If Yes, what type of study was conducted (e.g., return on investment, business case analysis)?

2. What criteria did/does your agency use to determine where to place electronic signage? Please check all that apply.

- ☐ Boarding counts at stops/stations
- ☐ Number of transfers at stop/station
- ☐ Number of lines/routes at stop/station
- ☐ Outdoor versus indoor mounting needs
- ☐ Availability of power
- ☐ Environmental considerations
- ☐ Availability of communication
- ☐ Security considerations
- ☐ Physical obstructions/visibility
- ☐ Safety considerations
- ☐ Existence of alternate media to provide transit information
- ☐ Mounting infrastructure
- ☐ Signs at all BRT/light rail/subway/commuter rail stations

Other (please specify)

3. Generally, do you consider providing real-time transit information via at least two dissemination media?

- ◯ Yes
- ◯ No
- ◯ Not sure

Use of Electronic Passenger Information Signage in Transit

4. Generally, does your agency consider providing real-time information in BOTH audio and visual formats?

- ◯ Yes
- ◯ No
- ◯ Not sure

5. Does your agency provide real-time information (and related information) to third parties for the purposes of developing mobile applications?

- ◯ Yes
- ◯ No

Use of Electronic Passenger Information Signage in Transit

16. Contribution of Providing Transit Information on Electronic Signage to Agen...

1. Does your agency have a Communications Strategy?

- ◯ Yes
- ◯ No
- ◯ Not sure

2. If Yes, is using electronic signage to provide transit information part of that Strategy?

- ◯ Yes
- ◯ No

3. Does your agency consider providing transit information on electronic signage s a way to attract "choice" riders?

- ◯ Yes
- ◯ No
- ◯ Not sure

4. Did the deployment of electronic signage to display transit information result in an increase in ridership?

- ◯ Yes
- ◯ No
- ◯ Not sure

Use of Electronic Passenger Information Signage in Transit

17. Wrap-up Questions

1. If Yes, how much did ridership increase as a result of disseminating information via electronic signage?

Percent ridership increase

2. If your agency has conducted surveys and/or focus groups to determine the usage of the information displayed on the electronic signage among your ridership, can you provide the survey results (via email)?

- Yes
- No

3. Has your agency developed a marketing campaign specifically about electronic signage to provide transit information?

- Yes. We would appreciate obtaining copies of the marketing campaign(s) via email.
- No
- Not sure

4. How do you gauge the customers' reactions to the electronic signage? Please check all that apply.

- Administer a survey or questionnaire
- Receive compliments or complaints about the signs
- Receive compliments or complaints about the service
- Measure ridership changes after electronic signage deployment

Other (please specify)

5. Does your agency include advertising on the same electronic signage that provides passenger information?

- Yes
- No

6. If Yes, how much revenue (in U.S. dollars) is generated from the advertising on an annual basis?

Annual revenue (in U.S. dollars)

Use of Electronic Passenger Information Signage in Transit

7. What is your agency's reason for including advertising or not including advertising on electronic signage?

8. Does your agency offer location-specific advertising on electronic signs (i.e., buy ads on a particular sign for a nearby business)?

- Yes
- No

9. Does your agency plan to deploy additional electronic signs in the future?

- Yes
- No
- Not sure

10. What is the one biggest problem associated with using electronic signage to display transit information? For example, what do you get the most complaints about from customers? Another example is that locating signs within existing bus shelters is the biggest problem.

11. What is the one biggest problem associated with operating and maintaining electronic signage to display transit information?

12. Please describe any additional "lessons learned" that would benefit other agencies that are considering using electronic signage to provide transit information.

Use of Electronic Passenger Information Signage in Transit

18. End of Survey

If you have any questions on the survey or this Synthesis project, please call or email Carol Schweiger at 857-453-5511 or clschweiger@transystems.com. Thank you very much for your participation in this important project.

APPENDIX B

List Of Agencies Responding To The Survey

Planning Data Analyst
AC Transit
1600 Franklin St.
Oakland, CA 94612

ITS Coordinator
Agence métropolitaine de transport (AMT)
700 rue de la Gauchetière, 26th Floor
Montreal, Quebec H3B 5M2 Canada

Manager, CSE
Bay Area Rapid Transit District (BART)
300 Lakeside Drive, #1531
Oakland, CA 94612

Blacksburg Transit
2800 Commerce Street
Blacksburg, VA 24060

Project Leader
Brampton Transit
130 Sandalwood Pkwy. W.
Brampton, Ontario L7A 0L1 Canada

IT Project Management Officer
Capital Metropolitan Transportation Authority
2910 East 5th Street
Austin, TX 78702

Senior ITS Developer
Central Florida Regional Transportation Authority
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APPENDIX C

Total Annual Ridership For Each Responding Agency

This section will contain the total annual ridership for each responding agency.

Agency Name	No. Indoor LED	No. Out-door LED	No. Indoor LCD	No. Out-door LCD	Ridership (2010 Annual Unlinked Trips)*
Alameda–Contra Costa (AC) Transit		80			61,390,737
Agence métropolitaine de transport (AMT)**	55	50	20	200	1,590,000—bus 18,422,800—commuter rail
Bay Area Rapid Transit (BART)	148	248			108,297,950
Blacksburg Transit					3,363,824
Brampton Transit**		50	5		17,686,000
Capital Metropolitan Transportation Authority (CMTA)		18			34,814,353—bus 120,788—commuter rail
Central Florida Regional Transportation Authority (a.k.a. LYNX)			1	3	24,780,704
Central New York Regional Transportation Authority	5	13			11,981,595
Centre Area Transportation Authority (CATA)		2	1	1	7,195,031
Charlotte Area Transit System		60			20,361,037—bus 3,250,020—light rail
Chattanooga Area Regional Transportation Authority (CARTA)	1	7			2,631,013
Chicago Transit Authority (CTA)	192	768		120	306,023,976—bus 210,849,074—subway
City of San Luis Obispo Transit/SLO Transit		6			1,019,852*
City of Wichita, KS	1	7			2,210,177
GO Transit**					17,012,400—bus 47,865,200—commuter rail
Hillsborough Area Regional Transit Authority (HART)	2		5		12,665,359—bus 501,959—light rail
Ixxi—RATP Group (Paris)					Not available
Kansas City Area Transportation Authority (KCATA)		114			14,610,848
King County Metro		48			32,281,667—bus 2,903,718—trolleybus 59,964—light rail
Madison Metro Transit	1	7			13,623,461
Massachusetts Bay Transportation Authority (MBTA)	350	363	1		108,128,006—bus 139,039,529—subway 36,909,924—commuter rail 65,471,593—light rail 3,124,729—trolleybus
Metropolitan Transportation Authority (MTA), New York City Transit (NYCT)	950	350	5		829,179,926—bus 2,439,158,966—subway
Mobility Lab			4		Not applicable
Monterey–Salinas Transit (MST)		30	3		4,249,622
Network Rail Infrastructure Ltd.	100		12		Not available

Table continued on p.100

Table continued from p.99

Agency Name	No. Indoor LED	No. Out-door LED	No. Indoor LCD	No. Out-door LCD	Ridership (2010 Annual Unlinked Trips)*
NJ Transit	50	100	200	400	162,224,375—bus 82,223,534—commuter rail 21,491,188—light rail
Pinellas Suncoast Transit Authority (PSTA)	25				12,811,835
rabbittransit		2	3		1,397,156
Region of Waterloo (Grand River Transit)		60	9		Not available
Regional Transportation Commission of Washoe County (RTC)					7,474,905
Société de transport de Laval		84	6		Not available
South Yorkshire Passenger Transport Executive***		180	220	21	110,809,000—bus 9,188,000—rail 14,931,000 - tram
Transport For London (TfL)****		2,500			2,344,000,000—bus 1,171,000,000—Under-ground 86,000,000—Docklands light rail 28,500,000—Tramlink 102,600,000—Over-ground Rail
Tri-County Metropolitan Transportation District of Oregon (TriMet)		118		84	60,508,249—bus 42,452,640—light rail 306,228—commuter rail
Urban Public Transport Organisation of Thessaloniki	1,200	220	20		Not available
Utah Transit Authority (UTA)	80	130			21,716,864—bus 13,400,546—light rail 1,389,872—commuter rail
Votran					3,235,767

*Unless indicated otherwise, figures come from the National Transit Database, Annual Transit Profiles (http://www.ntdprogram.gov/ntdprogram/data.htm).
** Derived from figures in American Public Transportation Association Transit Ridership Report, First Quarter 2012, http://www.apta.com/resources/statistics/Pages/ridershipreport.aspx.
*** Obtained from http://www.sypte.co.uk/PublicTransportPerformance.aspx.
**** Obtained from http://www.tfl.gov.uk/assets/downloads/corporate/Item15-TfL-Annual-Report.pdf.

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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