Use and Deployment of Mobile Device Technology for Real-Time Transit Information

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TRANSIT COOPERATIVE RESEARCH PROGRAM

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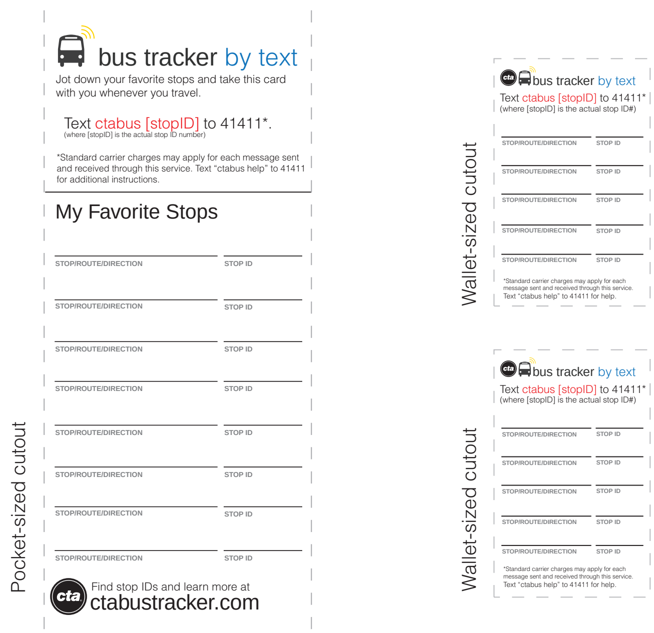

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A Synthesis of Transit Practice

TRANSPORTATION RESEARCH BOARD
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TRANSIT COOPERATIVE RESEARCH PROGRAM

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A Synthesis of Transit Practice

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative nearterm solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions*, published in 1987 and based on a study sponsored by the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

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The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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THE NATIONAL ACADEMIES

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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

The purpose of this report was to document the state of the practice in the use and deployment of real-time transit information on mobile devices using the following five dimensions: (1) the underlying technology required to generate the information to be disseminated, (2) the mobile technology used for dissemination, (3) the characteristics of the information, (4) the resources required to successfully deploy information on mobile devices, and (5) the contribution of mobile messaging to an overall agency communications strategy, including "information equity." One of the key results of the survey indicated that many of the respondents are using either third-party mobile content/applications providers or individuals to provide real-time information on and develop applications for mobile devices. This result confirms that many transit agencies have limited internal resources to develop, manage, and maintain real-time mobile applications.

The report offers a literature review; results of a survey conducted about items in the five dimensions, as well as questions regarding lessons learned; and the results of telephone interviews conducted with key agency personnel. The results of four of these telephone interviews are presented as case studies with noteworthy agency approaches to providing mobile information. Twenty-eight completed survey responses were received from 28 transit agencies around the world, a 100% response rate. The 15 U.S. transit agencies that provide real-time information on mobile devices responded, as well as 13 survey responses from international agencies.

Carol L. Schweiger, TranSystems Corporation, Boston, Massachusetts, collected and synthesized the information and wrote the paper, 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

USE AND DEPLOYMENT OF MOBILE DEVICE TECHNOLOGY FOR REAL-TIME TRANSIT INFORMATION

SUMMARY

Customer information is often a critical element of public transit authorities' strategy not only for providing transportation services but also for encouraging and facilitating the use of these services. The expectations of riders and nonriders help define the parameters within which agencies provide information. In meeting these expectations, agencies consider that customer information must be relevant, accurate, timely, and targeted to meet a diverse number of needs that reflect their communities, and it is important that it be available in different formats by means of a wide range of dissemination media/channels. In *TCRP Synthesis 68: Methods of Ridership Communication,* three of the factors governing effective communication are the stage of the travel chain in which the communication is needed, the demographic characteristics of the communications recipients, and their ownership of and ability to use technology. Mobile technology, specifically mobile phones and smartphones, is one way for agencies to address these factors.

The demographics of transit riders have changed significantly over the past 5 years, with many more riders and nonriders using cell phones or even smartphones, which provide Internet access and other capabilities such as mobile e-mail and application programs. This change has prompted transit agencies to look beyond providing information by means of traditional dissemination media such as dynamic message signs, which require more resources to implement (e.g., costs 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.

Starting in the early 2000s, many transit agencies in the United States began to offer static information on mobile devices, including timetables, service alerts, and trip planning. At that time, there were a limited number of mobile devices on the market, meaning that some agencies could develop simple applications for these devices in-house without significant expenditures. For example, in the late 1990s and early 2000s, Bay Area Rapid Transit in the San Francisco Bay area developed its own applications for the Palm operating system (OS). However, since that time, the explosion of mobile devices on the market has made it virtually impossible for agencies to keep current on the types of devices and their specific requirements and to develop, manage, and maintain mobile applications for these devices. These developments, coupled with the fact that agencies can now provide more types of customer information, caused agencies to look outside their organizations for third parties to assist them in providing information on mobile devices.

This synthesis examines and documents the state of the practice in the use and deployment of real-time transit information on mobile devices using the following five dimensions:

- The underlying technology required to generate the information that will be disseminated on mobile devices, including the underlying software, hardware, and communications;

- The mobile technology used for information dissemination, including handset capabilities, and the specific mobile delivery channels used, such as text messaging [also known as short message service (SMS)], mobile Internet, and smartphone applications;
- The characteristics of the information, including message types, content, format, accessibility, and method of dissemination (push/pull); the use of standards; and the reliability and accuracy of the information;
- The resources required to successfully deploy information on mobile devices, including capital and operations and maintenance costs, agency staff requirements, customer costs, and other resources (e.g., managing an external application development program); and
- The contribution of mobile messaging to an overall agency communications strategy, including "information equity." Here, information equity is defined as providing real-time information by means of at least two dissemination media in both audio and visual formats.

This synthesis includes a review of the relevant literature, in addition to the results of a survey that was conducted as part of this project. This survey included items in the dimensions described earlier, as well as questions regarding lessons learned in deploying real-time information on mobile devices. This synthesis also contains the results of interviews with key personnel at agencies that have exemplary approaches to providing mobile information.

The literature review revealed a wealth of material on the subject of providing real-time information on mobile devices. The literature that focuses on the development of innovative mobile applications, use of mobile device technology to enhance real-time information (e.g., device location), and use of social networking is also plentiful and covers both U.S. and international studies. Four major conclusions resulted from the literature review. First, the underlying technologies required to generate the real-time information provided on mobile devices are well understood. Several recent studies have documented the most innovative uses of the underlying technologies. For example, two European agencies describe combining real-time information with trip planning and providing this capability on mobile devices. Second, the literature confirms that it is important to consider certain characteristics of mobile technology when providing real-time information on mobile devices. Several papers discuss these factors, including mobile messaging reliability and usability, handset display dimensions, memory and processing speed, and access to communications networks. Third, although the deployment of real-time information on mobile devices is growing in the United States, there has been more deployment in Europe and Asia. However, the development of mobile applications based on "open data" is more prevalent in the United States. There is a distinct difference between the United States and Europe and Asia in embracing an open-data approach. Finally, using mobile phone location and social networking is revolutionizing the provision of real-time information on mobile devices. Even though the regulations governing mobile phone location tracking vary among the United States, Europe, and Japan (Linda Ackerman, James Kempf, and Toshio Miki, "Wireless Location Privacy: Law and Policy in the United States, EU and Japan," Internet Society, Nov. 2003, http://www.isoc.org/briefings/015/), the use of mobile device location capability allows current location data to be combined with real-time information. And mobile devices can use real-time information provided by means of social networking sites, such as Twitter.

The survey conducted as part of this synthesis covered the five dimensions mentioned earlier. Surveys were received from 28 transit agencies (100% response rate) around the world, including 10 international agencies. All responses represent agencies that carry more than 3.9 billion passengers annually (with the exception of Transport for London and Rejseplanen A/S in Valby, Denmark), with more than 1.4 billion in the United States.

The deployment of real-time information on mobile devices has not been specifically documented by the FTA or APTA. However, in reviewing the websites of the 276 U.S. transit agencies (APTA Membership Directory, Regular US Transit Systems, https://www.apta-gateway.com/eweb/DynamicPage.aspx?Webcode=APTAMembershipSearch, accessed May 18, 2010) that are members of APTA, approximately 45 of them provide some information on mobile devices, with approximately 15 of the 45 providing real-time information on mobile devices. In the United Kingdom, according to Knoop and Eames (*Public Transport Technology in the United Kingdom: Annual Survey 2008*, prepared for Real Time Information Group, RTIG Library Reference RTIG-PR010-D001-1.2, pp. 25–29, http://www.rtig.org.uk/web/docs/PDF/Downloads/RTIG-PR010-D001-1.0-Survey-2008.pdf), virtual dissemination of real-time information, including the use of mobile devices [SMS and wireless application protocol (WAP) devices], covered a total of 105,099 stops in 2008, with a projection of 119,081 stops in 2010.

Real-time information provided by means of SMS requires the mobile user to send a text message formatted in a specific way to a five- or six-digit common short code. The user will receive a text message back containing the requested information.

The synthesis survey covered the five dimensions of mobile real-time information and requested lessons learned. The 28 responding agencies' annual ridership ranged from 1 million (fixed-route bus and tourist van respondent) to 101.5 million (Tri-County Metropolitan Transportation District of Oregon) to 1 billion (National Rail in the United Kingdom).

In terms of the characteristics of the underlying technology required to generate the information that is disseminated on mobile devices, the mobile devices and operating systems, and the actual mobile messages, the survey responses indicated that the top seven most prevalent underlying technologies are as follows:

1. Real-time arrival prediction software (89% of respondents)
2. Automatic vehicle location (82%)
3. Computer-aided dispatch (64%)
4. Two-way messaging capability [e.g., using SMS (text messaging)] (57%)
5. Alert subscription system (46%)
6. Schedule adherence functionality (46%)
7. Onboard data communication system (39%)

Survey respondents reported a wide variation in the types of real-time information and the frequency with which it is updated. The most prevalent type of information that is updated on an ongoing basis is next vehicle arrival/departure prediction time, followed by information on planned detours, display/announcement of the current route and destination, identification of service disruptions, and schedule information during special events. As expected, the most prevalent information updated based on a specific threshold or time period is next vehicle arrival/departure prediction time.

In terms of dissemination media, mobile media (mobile web/Internet, smartphone applications, and two-way SMS) were some of the most prevalent. This was expected, as the survey was targeted at agencies that use mobile media in addition to more traditional dissemination channels. One of the reasons mobile technology was deployed was to provide real-time information more cost-effectively. However, few (4 of 28) respondents conducted a study to determine whether or not real-time information on mobile devices should be deployed. As discussed in the subsection on mobile technology in chapter three, this would indicate that business cases or models are not being conducted or constructed to determine whether or not to provide information on mobile devices.

One of the key results of the survey indicated that many of the respondents are using either third-party mobile content/applications providers or individuals to provide real-time information on and develop applications for mobile devices. This result confirms that many transit agencies have limited internal resources to develop, manage, and maintain real-time mobile applications.

The types of mobile services provided by the respondents are shown in Figure 26 (in chapter three). This list is purely for informational purposes and does not imply any endorsement by TRB or its sponsors. For the most part, mobile services are available on both conventional mobile phones and smartphones. The mobile operating systems used by the respondents' mobile services are as follows:

- iPhone OS (50% of respondents reported using this mobile operating system)
- Windows Mobile (46%)
- Palm OS/Palm webOS (36%)
- Research in Motion (36%)
- Pocket PC (32%)
- Symbian OS (32%)
- Android (32%)
- Maemo (Nokia) (25%)
- Mobile Linux (21%)
- bada (Samsung) (18%)

The characteristics of the real-time information on mobile devices covered the format of SMS requests and the format of the real-time information returned to the mobile user. Many systems have similar formatting for SMS messages because SMS has a limit of 160 Latin characters. The format of mobile websites containing real-time information varies depending on how the agency uses the phone or smartphone screen real estate. The formats of third-party mobile applications of real-time information vary greatly.

Another key component of mobile real-time information is whether it is provided on a push (information pushed to customer under specific circumstances) or pull (accessing a mobile website or requesting information on-demand) basis. Survey respondents indicated that the selection of push versus pull would depend on the actual use of the information and the customer's location in the "trip chain" when accessing information. (A trip chain is the connection of all the consecutive steps in a transit trip from origin to destination. For example, a trip chain might include walking from the origin to a bus stop, boarding a bus at the bus stop, alighting the bus at a subway station, boarding a subway at the station, alighting at another subway station, and walking to the final destination.) Further, respondents thought that the use of pull provides customers with the latest information when they want it.

A wide variety of standards were used in providing mobile information, but they can be separated into two categories: those that relate to the specific transit information (e.g., identification of fixed objects in public transport) and those that relate to the formatting of the information (e.g., wireless application protocol).

As discussed in prior syntheses (*TCRP Synthesis 68: Methods of Ridership Communication* and *TCRP Synthesis 48: Real-Time Bus Arrival Information Systems*) and an FTA project on real-time information (*Guidance for Developing and Deploying Real-Time Traveler Information Systems for Transit*), a limited number of respondents monitor the reliability and accuracy of the information provided on mobile devices. However, the agencies that monitor reliability and accuracy provided brief descriptions of their monitoring process. For example, one agency relies on its vendor to ensure accuracy and reliability. In another agency, ongoing monitoring is performed at 5-min intervals, field verification is done quarterly, and customer feedback is used to identify problems. Another agency uses system reliability measurements that are taken each month based on the “uptime” of its system. Depending on how well the system scores, this agency has contract language that allows it to monetarily penalize the system contractor up to $10,000 per month. Another agency has built logic into the application to monitor accuracy. Another agency is defining its performance monitoring procedures, which will likely include comparing information received by the mobile device with what the user is actually experiencing.

In terms of resource requirements, data were collected on the capital, operations and maintenance costs, and agency labor requirements. The data reported by agencies were limited, indicating that agencies are not fully aware of the costs and labor requirements to provide real-time information on mobile devices. As expected, almost half of the respondents said that their information technology departments were responsible for deploying mobile information, with a little over 30% stating that their customer service departments were responsible.

This synthesis revealed that mobile real-time information definitely contributes to agencies’ communications strategies. Chapter five contains information on how many survey respondents have a communications strategy and how many consider mobile information as part of their strategies. Further, respondents reported that they consider information equity when choosing dissemination media, and that providing real-time information on mobile devices is a way to attract “choice” riders. (Here information equity is defined as providing real-time information for every station or stop by means of at least two dissemination media/channels using both visual and audio formats. This will ensure the all riders have equal access to the information.) Finally, chapter five provides examples of web-based marketing of mobile information, along with a brief discussion of the opportunities to pursue advertising revenue through mobile information.

The four key results of the synthesis are as follows:

- Although a limited number of transit agencies in the United States provide real-time information on mobile devices as of May 2010, there is a growing trend toward deploying this technology.
- Using a third party to develop real-time applications and provide real-time information on mobile devices is overwhelmingly the approach that transit agencies are taking.
- The costs of providing real-time information on mobile devices are not well understood and are discussed in only a limited way in the literature and survey responses.
- The overall lessons learned that would benefit transit agencies that are considering providing real-time information on mobile devices are as follows:
  - An executive or board sponsor is critical to deploying this type of technology. Without this “champion,” it is a challenge to obtain and maintain agency departments’ interest.
  - An architecture with a central source of all real-time information is important (from a regional perspective). This simplicity has been instrumental in the implementation.
  - It is important that the source data (from the automatic vehicle location system) be verified thoroughly from a reliability and accuracy standpoint.
  - Collecting usage statistics to indicate customer preferences among voice, SMS, mobile web, smartphone, etc., is important.
  - It may be useful to test the real-time information on the Internet first, and then deploy it on a mobile website.
  - It is worthwhile to have only one service provider that knows the market, the new technology, and the agency’s data structure, interfaces, databases, and web services.

- Strong relationships with communication providers and mobile device suppliers are critical.
- The "one customer" approach (regardless of the mode of travel being used or the information that is being requested) with one application (or suite of applications that are rationalized) is an important driver. Users do not want to change between car parking, bus, train, subway, walking, and wayfinding applications; they prefer one application that is smart enough to respond to their needs. Further, the integration of ticketing and these applications may be a useful consideration.

The five key conclusions resulting from the synthesis are summarized as follows:

- One of the most critical considerations for providing real-time information on mobile devices is the agency's ability to develop, manage, and maintain mobile applications in-house or manage third-party application development and services.
- There is a strong relationship between the open-data approach and the resources necessary to create useful and accurate real-time mobile applications.
- Providing real-time transit information on mobile devices is beginning to be more prevalent than the use of other more traditional dissemination media, such as dynamic message signs and interactive voice response.
- Although using third parties to develop innovative real-time mobile applications definitely saves resources, agencies might consider that not all existing and potential customers will have mobile devices, and that not all applications will satisfy the needs of all customers.
- Personalization of information is critical to the success of providing information on mobile devices.

It should be noted that since this synthesis was initially written, many key developments related to the synthesis topic have taken place. The most significant development is in the area of "open data." Between January and September 2010, the number of U.S. agencies with open data has increased from 102 to 113 ("Simplifying the Open Transit Data Debate: A Comprehensive Guide to Providing Real-Time Information to Your Passengers," Feb. 8, 2010, http://www.mentoreng.com/blog/index.php/2010/02/simplifying-the-open-transit-data-debate-a-comprehensive-guide-to-providing-real-time-information-to-your-passengers/ and http://www.citygoround.org/agencies/us/?public=all). For example, after the initial draft of this report was prepared, Transport for London began providing free access to data that were either unavailable to the public or were restricted, the New York Metropolitan Transportation Authority opened its schedule data to the public, and the Washington Metropolitan Area Transit Authority opened its real-time data to the public. Other developments, such as the Tri-County Metropolitan Transportation District of Oregon providing real-time information by text message, occurred in August 2010. This report covers the most relevant developments that occurred on or before September 2010, when the final version of this report was completed.

CHAPTER ONE

INTRODUCTION

PROJECT BACKGROUND AND OBJECTIVES

The proliferation of mobile phones and smartphones has resulted in high levels of reliance on these devices to provide basic and personalized communications. The increasing use of these devices provides many opportunities for information dissemination by private and public transportation entities. Further, public transit customers have relatively high expectations for real-time information at all stages of their trips. These expectations, combined with the rapidly increasing and widespread use of mobile devices, have led many transportation agencies in the United States and abroad to provide information through mobile devices. One additional factor in providing transit information by means of mobile devices is the functional capabilities of these devices [e.g., location service, Internet browsing, and short message service (SMS)]. Finally, with U.S. transit agencies facing decreasing budgets, providing information by means of mobile devices ("virtual" dissemination) may be more cost-effective than disseminating information through more costly infrastructure, such as dynamic message signs (DMSs).

Supporting the myriad mobile devices and platforms available in the marketplace has become a challenge as well. Agencies are turning to third parties that are familiar with the most current devices and platforms to ensure that the information can be made available on a variety of mobile devices without having to employ staff that is knowledgeable about all the platforms. Not only is this a more cost-effective approach to providing the information, but it also ensures that customers will have access to the information regardless of the type of device they are using.

This synthesis examines and documents the state of the practice in the use and deployment of real-time transit information on mobile devices using the following five dimensions. The first dimension is the underlying technology that is required to generate the information that will be disseminated on mobile devices. This dimension covers the required underlying software, hardware, and communications. The second dimension is the mobile technology used for information dissemination, including handset capabilities, and the specific mobile delivery channels used, such as text messaging (SMS), mobile Internet, and smartphone applications. The third dimension covers the characteristics of the information, including message types, content, format, accessibility, and method of dissemination (push/pull); the use of standards; and the reliability and accuracy of the information. The fourth dimension covers the resources required to successfully deploy information on mobile devices, including capital, operations, and maintenance costs; agency staff requirements; customer costs; and other resources (e.g., managing an external application development program). The fifth and final dimension is the contribution of mobile messaging to an overall agency communications strategy, including "information equity." Here, *information equity* is defined as providing real-time information by means of at least two dissemination media in both audio and visual formats.

The primary focus of the synthesis is on determining the experience with providing real-time information on mobile devices in the United States and abroad, and how agencies are using this dissemination channel to serve the needs of their customers. The synthesis includes a brief discussion using social media on mobile devices as an additional way of providing real-time transit information.

A review of the relevant literature in the field is combined with surveys of selected transit agencies and other appropriate stakeholders to report on the current state of the practice. The survey was designed to obtain information on the aforementioned dimensions of providing real-time transit information on mobile devices, including the characteristics of the underlying technology that generates the real-time information, the mobile devices and the mobile displays/messages, the required resources, and agencies' experience with providing mobile information, particularly the role that mobile information has in an agency's communications strategy. Based on survey results, several case studies were developed to describe innovative and successful practices, as well as lessons learned and gaps in information. An important element of this report is the documented interviews with key personnel at agencies that provide real-time information on mobile devices.

TECHNICAL APPROACH TO THE PROJECT

This synthesis project was conducted in five major steps. First, a literature review was performed to identify the characteristics of the underlying technology, mobile devices, and mobile information/messages; resources required to deliver information by means of mobile devices; and contribution of mobile information/messages to an agency's communications strategy. See the References for a list of references and Appendix A for a complete list of literature reviewed.

Second, a survey was conducted to collect information on factors such as types of underlying technology; types of mobile technology and delivery channels used; characteristics of mobile information, use of standards, and the reliability and accuracy of the information; and necessary resources to deploy real-time mobile information. In addition, information regarding how mobile messaging contributes to an agency's overall communications strategy was explored through the survey. The survey instrument is in Appendix B, and the list of agencies responding to the survey is in Appendix C.

Third, the survey results were analyzed. Fourth, telephone interviews were conducted with key personnel at agencies with experience providing real-time information on mobile devices. Chapter six presents case studies from selected agencies that have significant experience with providing information on mobile devices. Finally, the results and conclusions were prepared and documented.

REPORT ORGANIZATION

This report is organized as follows:

- Chapter two summarizes the literature review;
- Chapter three describes the underlying technology, mobile technology, mobile information, use of standards, and the reliability and accuracy of the mobile information;
- Chapter four presents information about the resources necessary to deploy real-time information on mobile devices;
- Chapter five discusses the contribution of mobile messaging to agency communications strategy;
- Chapter six presents case studies from selected agencies that have experience providing real-time information on mobile devices;
- Chapter seven summarizes the results of the synthesis and presents conclusions;
- Appendix A contains the bibliography for literature that was reviewed;
- Appendix B contains the survey instrument;
- Appendix C shows the list of responding agencies; and
- Appendix D provides additional information.

CHAPTER TWO

LITERATURE REVIEW

The literature review revealed that a wide variety of reports, papers, articles, and press releases have been written about providing real-time transit information on mobile devices. The literature is divided into the five dimensions as outlined in chapter one.

The first step of the literature review was to conduct an online Transportation Research Information Services (TRIS) search. This TRIS search yielded 31 documents, several of which were reviewed and used as input for this report. The second step was to obtain and review articles, press releases, and website information directly from agencies and mobile services vendors across the world. The third step was to review FTA, FHWA, and TCRP research reports. Finally, other papers and articles were obtained from various sources, including the following:

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

All documentation reviewed for the synthesis is listed in Appendix A.

UNDERLYING TECHNOLOGY

The literature reviewed in this dimension covered many of the technologies required to generate the information that will be disseminated on mobile devices, including automatic vehicle location system (AVL) software, computer-aided dispatch (CAD) software, software that calculates the real-time information from data generated by CAD/AVL systems, and software that provides the real-time information to mobile devices. First, as stated in *TCRP Synthesis 73*, 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" (*1*). Most of these underlying technologies have been the subject of numerous reports and articles; this synthesis describes these technologies briefly in chapter three.

The first demonstrations of using fleet management technologies, such as CAD/AVL, to provide real-time information were conducted in Europe in the mid-1990s (*2*). These projects included Advanced Transport Telematics in Urban Sites with Integration and Standardisation; Telematics Applications in Bavaria, Scotland and Others; and QUARTET PLUS. One of the first U.S. applications of providing real-time transit information on mobile devices using AVL data was described in "Wireless Internet Access to Real-Time Transit Information" (*3*) and "Real-Time Bus Information on Mobile Devices" (*4*). Although the technology discussed in these papers is somewhat outdated, the resulting application is still operational and has expanded to a variety of new mobile devices (*5*).

In the United Kingdom, the Real Time Information Group reported on the number of stops covered by virtual dissemination media, including mobile media, in 2008 (*6*):

> In 2008, approximately 25 local authorities [LAs] currently use a form of virtual dissemination to make RTPI [real-time passenger information] available to the public. The two most common choices of virtual dissemination methods were SMS and the LA website with 24 and 20 LAs offering this service respectively. By far, the greatest number of stops are covered by SMS (*6*, p. 25).

Second, one underlying technology not usually thought of as facilitating the provision of real-time information is trip-planning software. However, the integration of the aforementioned underlying technologies and trip-planning software to provide real-time information has been documented, is being demonstrated, and is operational in specific locations. One application of trip planning with real-time information using mobile devices, called the Transitr system, was demonstrated in three transit agencies in the San Francisco Bay area:

> It combines a user's geographic location with real-time transit information provided by transit agencies to determine the fastest route to a desired destination. It fuses real-time data feeds with the existing technology of schedule-based transit trip planners (TTPs) currently available online. . . . The system predicts the shortest paths between any two points in the transit network using real-time information provided by a third party bus arrival prediction system, relying on GPS [global

> positioning system] equipped transit vehicles. Users submit their origin and destination through a map-based iPhone application, or through a JavaScript enabled web browser. A server implementing a dynamic K-shortest paths algorithm with predicted link travel times returns personalized route directions for the user, displayed on a map. The results show that routing using the predicted bus arrivals marginally increases the accuracy of the total travel time and the optimality of the route (*7*).

Another mobile trip-planning application using real-time information has been deployed in Austria (*8*). The SCOTTY mobil application available from ÖBB-Personenverkehr is a mobile route planner that provides timetable information, retrieves regional maps, saves personal timetables, and provides real-time information on specific connections (*9*).

Yet another mobile application of trip planning using real-time information was developed for Verkehrsverbund Berlin–Brandenburg (VBB), which is the public transport authority of the Berlin–Brandenburg region in Germany (*10*, *11*). VBB-Fahrinfo is VBB's traveler information system that provides the following information by means of both the Internet and mobile devices:

- "VBB-Fahrinfo for all standard devices (based on XHTML [extensible hypertext markup language] technology) offering the full functionality which is available on the Internet; and
- "VBB-Fahrinfo Mobile, which is a version that has both offline and online functions offering a 'real time check' for connections that are saved on the device" (*10*, p. *5*).

After the deployment of this system, "The percentage of requests from mobile phones raised from less than 1% in January 2008 to around 13% in January 2009" (*10*, p. *6*).

Third, in areas that have multiple transit operators, one of the underlying technologies that is necessary to provide a traveler with consolidated real-time information is the integration of the information generated by the agencies'/operators' CAD/AVL systems. There are several ways to accomplish this integration, as noted by Bjersing (*12*). Three potential approaches to regional information integration are as follows (*12*, p. *2*):

- One system is used by all opérators/agencies;
- Each operator/agency uses its own system and exchange information with other operators/agencies systems; and
- Each operator/agency uses its own system and exchange information through a central integrator.

Depending on the region, the third approach (shown in Figure 1) can be the most beneficial, ensuring information consistency, allowing individual operators/agencies to select their own CAD/AVL systems, and providing the capability to add more operators/agencies. Stockholm Public Transport (SL; AB Storstockholms Lokaltrafik) uses this approach, as shown in Figure 2.

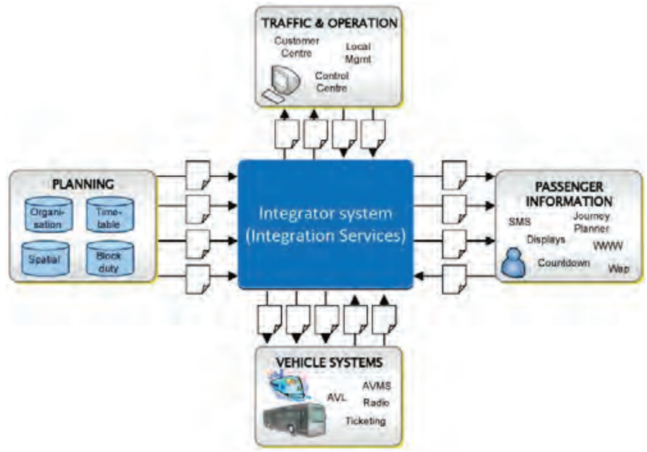


FIGURE 1 Approach to using a Central Information Integrator. [*Source*: (*12*, p. 10).]

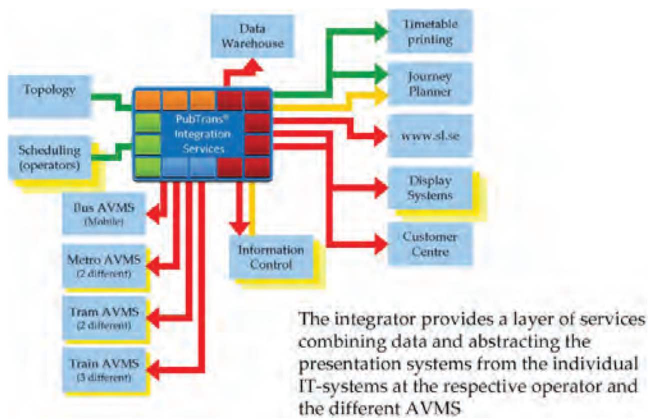


FIGURE 2 SL Integrator approach to providing transit information. [*Source*: (*12*, p. 13).]

Finally, from an intermodal perspective (with transit as one of the modes), a different approach is being used on a pilot basis in six European cities (Oslo, Norway; Munich, Germany; Brno, Czechoslovakia; Vienna, Austria; Florence, Italy; and Bucharest, Romania) to provide real-time information. The Intelligent and Efficient Travel Management for European Cities (In Time) project is a

> pan-European approach to RTTI [real-time traffic and travel information] service provision based on an open, standardised service oriented infrastructure and B2B [business-to-business] services that will facilitate access to urban traffic related data, RTTI service provision and interoperability by traffic information service providers (TISP). . . . The In-Time RDSS [regional data/service server] will be set up in all pilot sites to ensure the easy access of real-time multimodal traffic data for external TISPs. This model ensures the easy access to all urban traffic related data within one region resulting in the distribution to the end-users through several information channels and in parallel enhancing user acceptance (*13*, p. *2*).

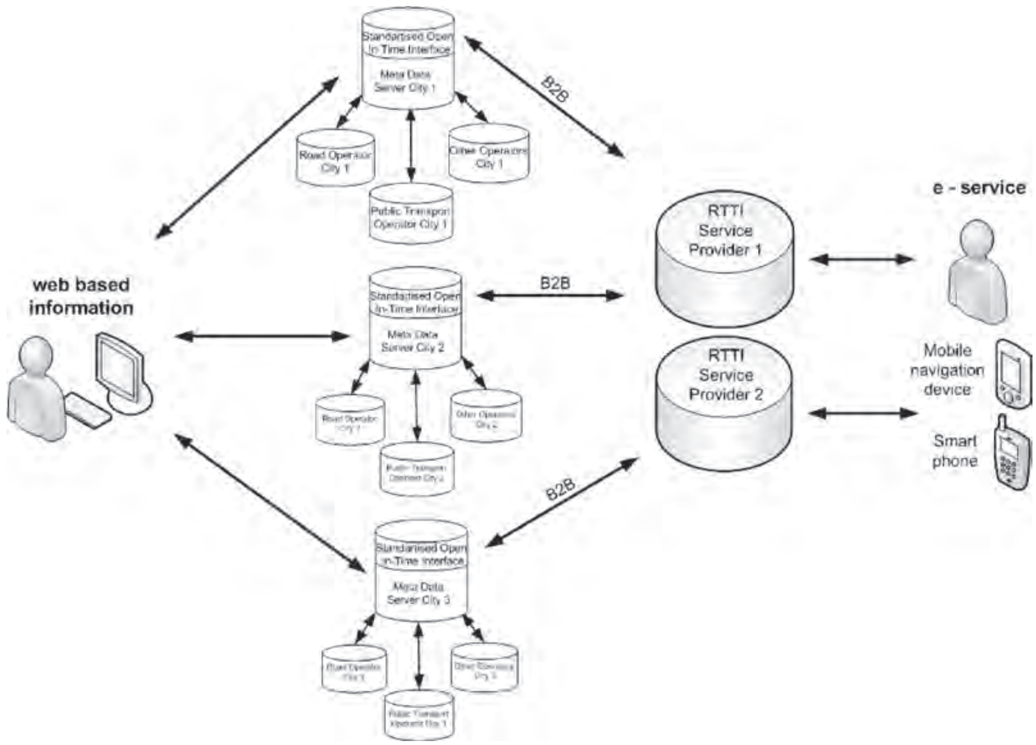


FIGURE 3 The concept of interoperable intermodal traveler information. [*Source*: (*13*, p. 3).]

Figures 3 and 4 show the interoperable intermodal traveler information and RDSS concepts, respectively.

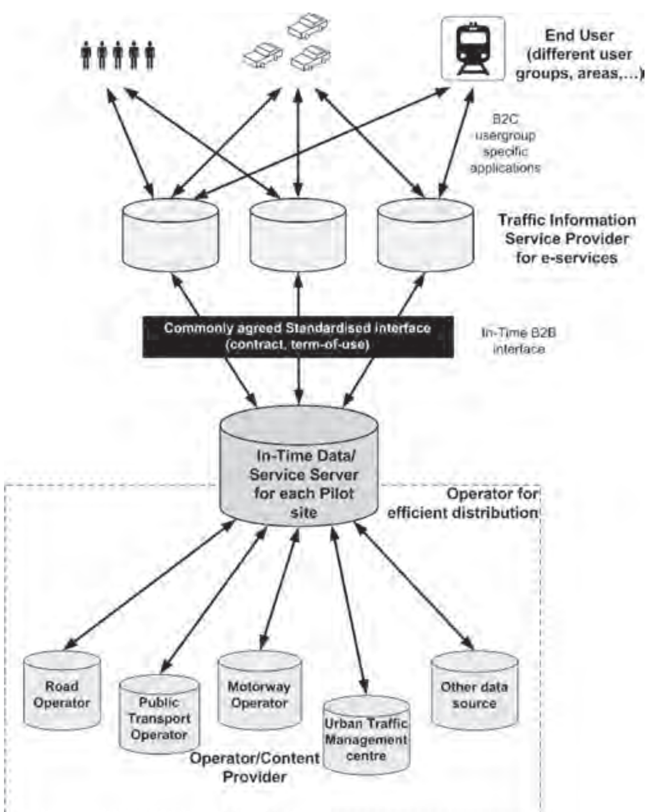


FIGURE 4 Concept of the In-Time Regional Data/Service Server (RDSS). [*Source*: (*13*, p. 5).]

MOBILE DEVICE TECHNOLOGY

The proliferation of mobile phones and smartphones has created a challenging environment in terms of developing real-time transit applications for mobile devices. "Analysts contend that the mobile market remains in a state of flux, leaving plenty of room for these companies to build momentum if they can create something that catches the attention of consumers" (*14*). This statement describes the state of the mobile phone and applications market as of May 2010, with a new mobile device being introduced every few weeks, and with devices having more and more capabilities. For example, as of May 2010, numerous new mobile phones and smartphones were introduced to the market—each from various manufacturers with various operating systems being offered by various mobile phone providers (*15*).

Mobile technologies can be divided into the following categories: type of mobile device, handset manufacturer, and mobile device operating system. The literature describes three major types of mobile devices: mobile phones with no Internet access (but with the capability to send/receive text messages), mobile phones with Internet access (and text messaging), and smartphones with the capability to run mobile application programs. The wide variety of mobile phone and smartphones on the market as of May 2010 included the following, which are listed for information purposes only and not as endorsement of any kind (*16*):

• Apple	• Motorola
• Casio	• Nokia
• Dell	• Palm
• Fujitsu	• Pantech
• Garmin-Asus	• Research in Motion
• Google	• Samsung
• Hewlett Packard	• Sanyo
• High Tech Computer Corporation	• Sharp
• LG	• Sony Ericsson
• Microsoft	• Vertu
• Mitsubishi	

There are several operating systems used by the mobile devices manufactured by these companies. As of May 2010, the most common mobile operating systems, listed for information purposes only and not as endorsement of any kind, were as follows (*17*):

- Android by Google
- bada from Samsung Electronics
- BlackBerry by Research in Motion
- iPhone OS by Apple
- Maemo (Debian OS) by Nokia
- MeeGo from Nokia and Intel
- Palm OS, Garnet, and WebOS
- Symbian by Nokia
- Windows Mobile by Microsoft

Given the large number of handsets and operating systems, their detailed characteristics vary widely. For example, communications technology [e.g., code division multiple access, global system for mobile communications, number of pixels on the display, number of colors on the display, standby/talk time (e.g., battery life), and GPS availability] varies widely among all available mobile devices.

There are three major mobile channels through which real-time transit information is provided: mobile web/Internet (including mobile social networking websites), short message service (SMS) (a.k.a. text messaging), and mobile e-mail.

> Mobile Web is the term used when the Internet is accessed by means of a cell phone, PDA [personal digital assistant], or other device with Internet capabilities (such as the Sony PSP™ or the Apple iPod Touch™). With the introduction of new phones and increasing technological capabilities, mobile web use in the United States has grown to over 95 million users in 2008 (*18*).
>
> SMS is
>
> the transmission of short alphanumeric text-messages to and from a mobile phone, fax machine and/or IP [internet protocol] address. As of September 2010, messages must be no longer than 160 alphanumeric characters and contain no images or graphics. (It is possible to send an SMS longer than 160 characters, but a longer message is divided into separate messages each with 160-characters.) Once a message is sent, it is received by a Short Message Service Center (SMSC), which must then get it to the appropriate mobile device (*19*).

An SMS message can be sent to a mobile device that is not turned on—the mobile network operator will store the SMS message and send it when the mobile device is turned on (*20*).

There are two types of SMS: pull and push. Pull technology is a situation in which someone makes a request for information by means of SMS, and then the requested information is provided to the requester through SMS. The reverse is known as push technology, in which a system pushes data to those subscribed to receive specific information. Push technology is a situation in which the request for a given transaction is initiated by a central system. Often, push services are based on information preferences expressed in advance by the user. For example, users may "subscribe" to receive various updates regarding the specific transit route or line they take on a regular basis. Whenever new content is available regarding those specific routes or lines, the system will push that information out to the users.

Real-time transit information provided by means of SMS is typically sent using a push approach—the customer requests specific information by sending a code to a predetermined common short code (CSC), a five- or six-digit number. For example, in Chicago, a customer can request real-time bus information for a specific stop by sending "ctabus 14624" to 41411 (the CSC), where 14624 indicates the bus stop at the intersection of Fullerton and Pulaski.

SMS is desirable over e-mail because "95% of text messages are read within four minutes (compare that to email which is 48 hours)" (*21*, p. 1). Further, if an agency uses an SMS vendor, it is recommended that the vendor "offers an SLA (Service Level Agreement) with guaranteed response times for support issues (SMS happens in real-time. Think 'American Idol' or the 'Dave Ramsey Show,' it's all live)" (*21*, p. 5). However, guaranteed response times may be challenging to honor because there can be situations beyond the SMS vendor's control (e.g., if there is a carrier or network outage).

In 2005, a mobile device application of real-time transit information by means of SMS called PredictBus was developed in Kuala Lumpur (*22*). As shown in Figure 5, PredictBus is "a mobile information service which is fully integrated with multiple technologies and information into one seamless system. The forecasting system is the ability to track the current location of a particular bus and estimate the arrival time of that bus to particular bus stop" (*22*, p. 1).

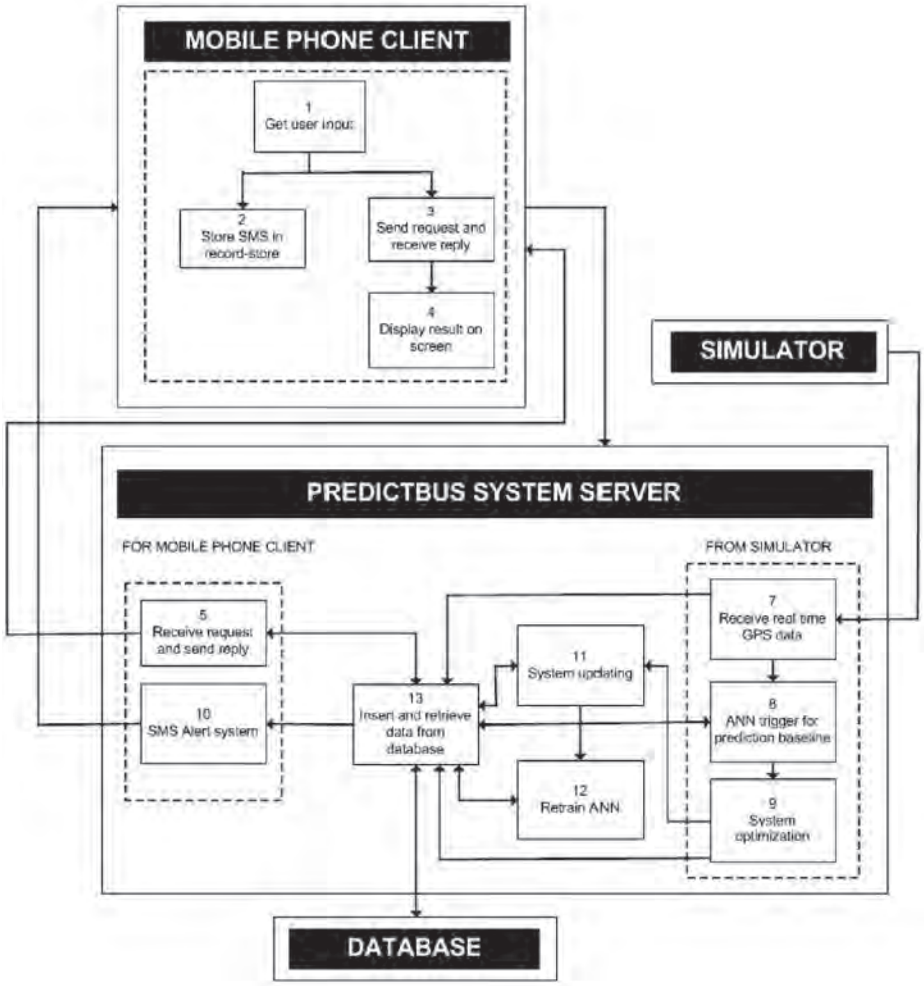


FIGURE 5 PredictBus System modules. [*Source*: (*22*, p. 91).]

CHARACTERISTICS OF THE MOBILE INFORMATION

Beyond the survey results presented in chapters three, four, and five, there are myriad reports that describe the characteristics of real-time information provided on mobile devices. First, the factors governing providing any information on mobile devices that should be taken into consideration include the following (*23*):

- Mobile screen "real estate" (i.e., dimensions),
- Type of browser used by the mobile device (because different browsers display information differently),
- Handset/hardware limitations in terms of memory and processing speed,
- Costs of mobile Internet access and SMS use for customers,
- Access to mobile phone networks, and
- Minimum of customer interaction with application.

Second, typical formatting of real-time information on mobile devices is shown in Figures 6–8. Figure 6 shows the mobile site providing real-time information by means of Traveline in the United Kingdom. "Nextbuses is a service that gives you the next bus times anywhere in Scotland, England and Wales straight to your mobile phone. It is designed to work on mobile phones that have internet" (*24*).

FIGURE 6 Real-time information available through Traveline. [*Source*: (*25*).]

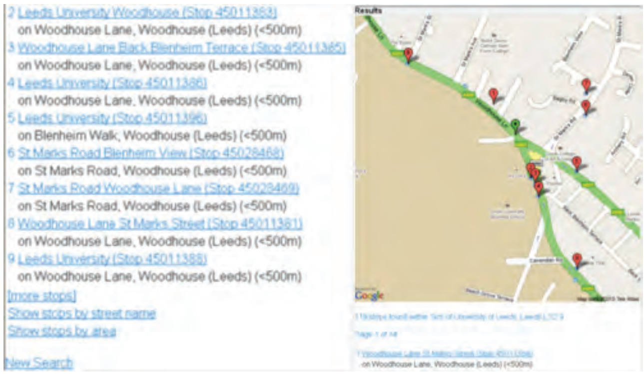


FIGURE 7 Traveline search for stops in Yorkshire.

fare by means of the application and save journey details for later use. KAMO users can track the progress of any buses, trams or underground trains included in the real-time positioning-based monitoring. The service also enables journey planning and tracking the planned route by means of mobile phone. Travel news concerning problems or changes to public transport is also available by means of the KAMO application. The mobile service developed by VTT is based on Near Field Communication (NFC) technology. Once loaded into the mobile phone, KAMO can be accessed using the phone's menu. RFID remote reading—featured by Nokia's 6131 NFC model, for example—enhances the speed of usage. Touching the RFID tag with a mobile phone opens the application on the phone's display without the user having to access it separately through the menu. Tags can be used for mobile travel ticket purchases or accessing stop-specific timetable information (*27*).

FIGURE 8 Real-time departures for Leeds University stop in Yorkshire.

Real-time information provided by SMS requires that the mobile user send a text message formatted in a specific way to a five- or six-digit CSC. The user will receive a text message back containing the requested real-time information. An example of real-time information through SMS is shown in Figure 9 (*26*).

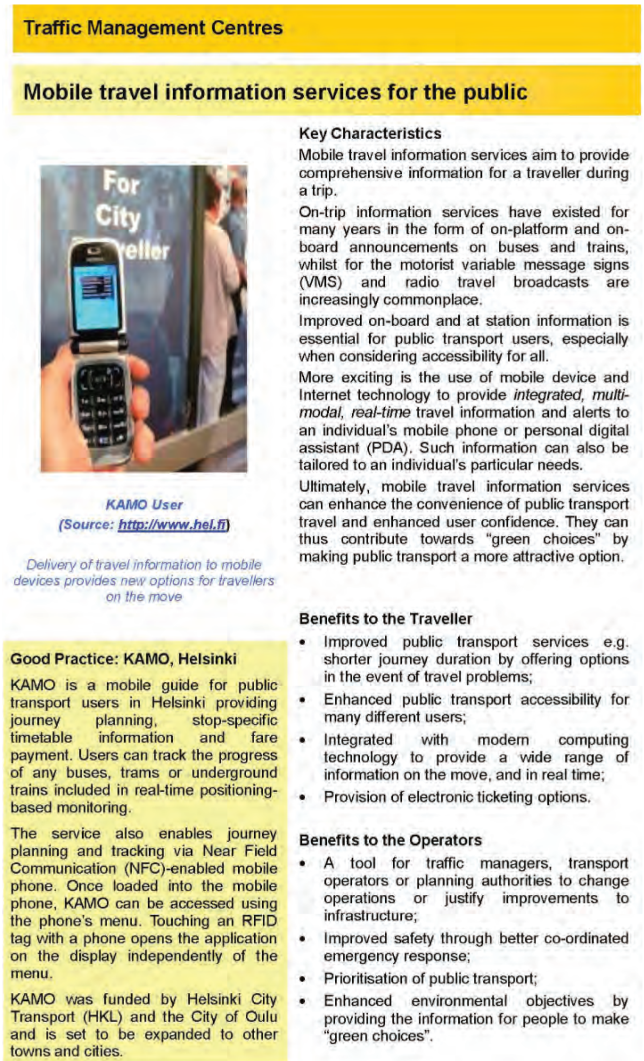
FIGURE 9 Example of requesting and receiving real-time transit information by means of SMS.

In Helsinki, Finland, real-time transit information on mobile devices was deployed in 2006, as shown in Figure 10.

The Mobile Guide for City Traveller (KAMO) is a new mobile application that offers journey planning and stop-specific timetable information. Passengers can also pay their

Another example of providing real-time information on mobile devices was developed to provide "a route-choice support system which helps passengers make appropriate decisions when train operation is disrupted. The system helps passengers decide whether to take the detour routes to their destinations or wait for the resumption of disturbed operation and continue their journey on the originally scheduled route" (*29*, p. 12). Figures 11 and 12 describe this system.

Third, the literature describes the reliability of mobile dissemination methods. For example, the use of SMS to provide real-time information must consider the reliability and timeliness of delivering the message. The delivery of a single text message depends on the reliability of many devices. "Each device in the path is highly specified, requires high performance, automatic recovery mechanisms and dependability. The user experience drives the success of the operators and suppliers. Suppliers must deliver high quality systems over and over again" (*30*). Providing real-time information by means of SMS is analogous to using SMS to deliver emergency or mission-critical messages owing to the require-



Traffic Management Centres

Mobile travel information services for the public

KAMO User
(Source: http://www.hel.fi)

Delivery of travel information to mobile devices provides new options for travellers on the move

Key Characteristics

Mobile travel information services aim to provide comprehensive information for a traveller during a trip.

On-trip information services have existed for many years in the form of on-platform and on-board announcements on buses and trains, whilst for the motorist variable message signs (VMS) and radio travel broadcasts are increasingly commonplace.

Improved on-board and at station information is essential for public transport users, especially when considering accessibility for all.

More exciting is the use of mobile device and Internet technology to provide *integrated, multi-modal, real-time* travel information and alerts to an individual's mobile phone or personal digital assistant (PDA). Such information can also be tailored to an individual's particular needs.

Ultimately, mobile travel information services can enhance the convenience of public transport travel and enhanced user confidence. They can thus contribute towards "green choices" by making public transport a more attractive option.

Good Practice: KAMO, Helsinki

KAMO is a mobile guide for public transport users in Helsinki providing journey planning, stop-specific timetable information and fare payment. Users can track the progress of any buses, trams or underground trains included in real-time positioning-based monitoring.

The service also enables journey planning and tracking via Near Field Communication (NFC)-enabled mobile phone. Once loaded into the mobile phone, KAMO can be accessed using the phone's menu. Touching an RFID tag with a phone opens the application on the display independently of the menu.

KAMO was funded by Helsinki City Transport (HKL) and the City of Oulu and is set to be expanded to other towns and cities.

Benefits to the Traveller

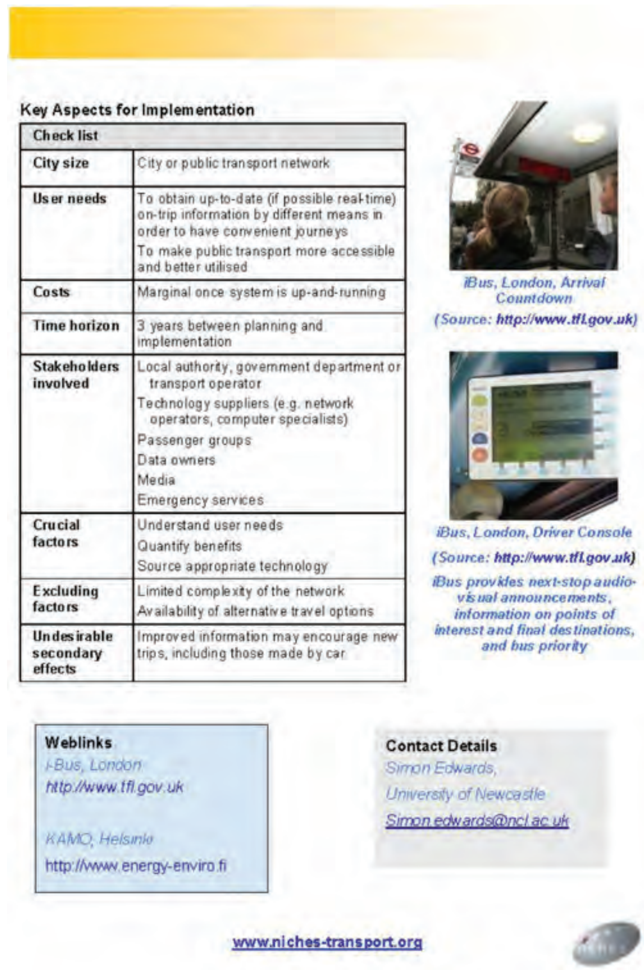
- Improved public transport services e.g. shorter journey duration by offering options in the event of travel problems;
- Enhanced public transport accessibility for many different users;
- Integrated with modern computing technology to provide a wide range of information on the move, and in real time;
- Provision of electronic ticketing options.

Benefits to the Operators

- A tool for traffic managers, transport operators or planning authorities to change operations or justify improvements to infrastructure;
- Improved safety through better co-ordinated emergency response;
- Prioritisation of public transport;
- Enhanced environmental objectives by providing the information for people to make "green choices".

FIGURE 10 KAMO system description. [*Source:* (*28*).]

ments of timeliness and reliability of the message delivery. "Neither the existing Short-Messaging Service (SMS) nor the existing Multimedia Messaging Service (MMS) are



Key Aspects for Implementation

Check list	
City size	City or public transport network
User needs	To obtain up-to-date (if possible real-time) on-trip information by different means in order to have convenient journeys To make public transport more accessible and better utilised
Costs	Marginal once system is up-and-running
Time horizon	3 years between planning and implementation
Stakeholders involved	Local authority, government department or transport operator Technology suppliers (e.g. network operators, computer specialists) Passenger groups Data owners Media Emergency services
Crucial factors	Understand user needs Quantify benefits Source appropriate technology
Excluding factors	Limited complexity of the network Availability of alternative travel options
Undesirable secondary effects	Improved information may encourage new trips, including those made by car

iBus, London, Arrival Countdown
(Source: http://www.tfl.gov.uk)

iBus, London, Driver Console
(Source: http://www.tfl.gov.uk)
iBus provides next-stop audio-visual announcements, information on points of interest and final destinations, and bus priority

Weblinks
i-Bus, London
http://www.tfl.gov.uk

KAMO, Helsinki
http://www.energy-enviro.fi

Contact Details
Simon Edwards,
University of Newcastle
Simon.edwards@ncl.ac.uk

www.niches-transport.org

FIGURE 10 (*continued*). KAMO system description. [*Source:* (*28*).]

suitable replacements for real-time voice emergency communications. SMS and MMS messaging that exists on cell phones today were not designed for real-time, 2-way communications and do not provide the level of reliability and the capabilities that are available in a voice 9-1-1 call (such

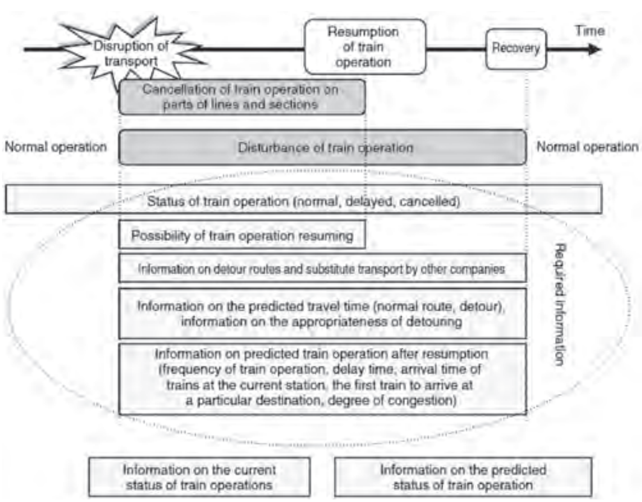


FIGURE 11 Information required by passengers during disrupted train operation. [*Source*: (*29*, p. 2).]

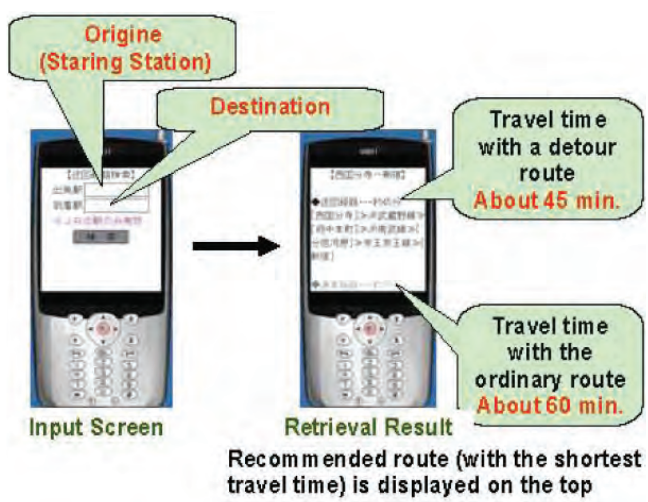


FIGURE 12. Route Choice Support System (Mobile version). [*Source*: (*29*, p. 8).]

as location, routing to the appropriate PSAP [public safety answering point], and callback capabilities). Considerations about legacy mobile device, mobile network, and PSAP system compatibility versus service expectations must be evaluated" (*31*). Further, in analyzing the reliability of SMS, "although the SMS service incorporates a number of reliability mechanisms such as delivery acknowledgement and multiple retries, our study shows that its reliability is not as good as we expected. For example, message delivery failure ratio is as high as 5.1% during normal operation conditions" (*32*, p. 1). Overall, it is important that the needs of mobile clients be considered when providing real-time information, including access to wireless networks, processing requirements, and status of the network (*33*).

In terms of the acceptance of mobile real-time information, Brian Caulfield and Margaret O'Mahoney describe the factors that influence user preferences for this information (*34*). In the pre-trip stage, individuals were found to derive the greatest utility from using an SMS, followed by the Internet and a call center. At the next stage of the trip, which is at a stop or station, respondents indicated that they would derive the greatest benefit from a passenger information display, with SMS being the next most important, followed by the call center. This result may be a product of the convenience and speed of accessing an SMS compared with those of a call center. At the pre-trip planning stage when at work returning home, respondents indicated that they would derive the greatest benefit from using an SMS, followed by a call center and the Internet. These findings demonstrate that at this stage respondents derive the greatest benefit from using an SMS. As with the first stage, this finding may be related to the convenience associated with using this method of real-time information compared with the other options (*35*).

RESOURCES REQUIRED TO PROVIDE MOBILE SERVICES

The literature provides a limited amount of information regarding this aspect of providing real-time transit information on mobile devices. For example, several references that describe the costs of real-time information do not give the specific costs of providing that information on mobile devices. Cham et al. (*36*) provide general costs for the underlying technology and real-time information software, dynamic message signs (DMSs), Internet services, and phone-based services.

After conducting a brief Internet search, the following customer costs were noted for one SMS containing real-time information:

- €0.30 per message for Dublin Bus;
- €0.30 per message for Irish Rail;
- $0.55 Australian dollars per message for Metlink in Melbourne, Australia;
- $0.30 Singapore dollars for Singapore Public Transport; and
- 25 pence per premium rate response text for SMS for Leeds (U.K.) Traveler Information.

Also, there is a cost to the agency to provide SMS information. In some cases, the customer pays both agency and customer costs; in other cases, the agency pays for all SMS fees except for the customer SMS fees imposed by the wireless carrier. For example, as of September 2010, the Tri-County Metropolitan Transportation District of Oregon (TriMet) offers SMS real-time arrival information at no cost to the customer (except for standard carrier-imposed text messaging costs) by displaying a short ad at the end of each message. See http://trimet.org/transittracker/bytext.htm (as of September 3, 2010).

According to the Common Short Code Administration (CSCA), the cost to an agency for a CSC is $500 per month for a random CSC and $1,000 per month for a "select" CSC (e.g., digits representing the agency's name). "A CSC may be leased for three- (3), six- (6), or twelve- (12) month terms" (*37*).

Another aspect of required resources is the costs and benefits to an agency to participate in an open transit data program. The literature generally discusses what is necessary for agencies to provide open data (*38*). This includes exporting their data using the general transit feed specification (GTFS) (see http://code.google.com/transit/spec/transit_feed_specification.html as of September 30, 2010). GTFS is a widely accepted format for publishing transit data and allows agencies to be included on Google Transit. Once the data are exported, an agency makes the data available through either a developer website (within the agency website) or another website that will host the data feed. Many agencies create a license agreement or terms of use agreement to govern how developers can use data. Finally, it is important that agencies keep developers aware of changes to schedule data and other pertinent information so that third-party applications provide accurate information.

As of September 2010, little information was available regarding the specific costs associated with participating in an open-data program. However, some of the agencies that have most recently created open-data programs state that open-data programs require resources to continuously ensure the integrity and accuracy of the data. However, these same agencies also tout the benefits to customers while saving the costs that would be necessary for the agency to develop these applications in-house. For example, Jay Walder, the New York Metropolitan Transportation Authority (MTA) Chief Executive Officer, stated that he hoped "that the tools that might be developed using the agency's data would help transform the city's transit system into an even more useful resource for residents much faster and cheaper than it could do so itself" (*39*). Further, at the end of 2009, the Massachusetts Department of Transportation (MassDOT) launched the first phase of its open data initiative by releasing real-time information for five bus routes. The data released to software developers included real-time GPS locations of buses and arrival countdown information for every bus route. Within just one hour of releasing this data, a developer built an application showing real-time bus positions. Within two months, more than a dozen applications had been created including websites, smart phone applications, SMS text message services, and 617 phone numbers. All of these applications were created at no cost to MassDOT or the Massachusetts Bay Transportation Authority (MBTA). In his first week on the job, MassDOT Transit Division Administrator and MBTA General Manager Richard Davey announced that real-time data would be provided for all routes throughout the entire bus system. The expanded rollout began in June and was completed yesterday [September 8, 2010] (*40*).

In terms of the benefits to agencies and customers, FleetBeat (*38*) cites the following:

- Free development of mobile applications,
- Increased ridership,
- Improved customer service,
- Time saved by agencies in developing customized applications,
- More accurate applications, and
- Positive image for agencies.

CONTRIBUTION OF MOBILE MESSAGING TO AN OVERALL AGENCY COMMUNICATIONS STRATEGY

A significant body of literature covers the topic of mobile messaging as a way to partially meet an agency's communications needs. The literature can be separated into three major topics: information equity, acceptance of mobile messaging, and the use of innovative techniques to enhance real-time information provided on mobile devices.

In terms of information equity, A. C. Rizos recognizes the conflict among the following current conditions in the United States:

- The proliferation of mobile device-based transit applications;
- The pressure on transit systems to deploy more customer information systems;
- Transit agencies facing serious financial difficulties;
- "The demographics of transit users, many of whom are socioeconomically disadvantaged, often do not have access to the latest (and still expensive) mobile devices, and who are also without other transportation options" (*41*, p. 1).

"As mobile-connected traveler information systems continue to mature and become the norm, how can we reconcile these issues to ensure equitable information delivery and consumption, and what are and will be the implications for the 'under-connected' to access information concerning a service which receives extensive public funding with a primary objective to secure accessibility and mobility for everyone? Obstacles to successful and informed transit use impede the sort of societal integration transit is supposed to enable, when some benefit from the trend and others cannot" (*41*, p. 1).

The topic of information equity was raised in reviewing the deployment of information on mobile devices as a way to reduce call center costs at the Orange County Transportation Authority (OCTA) in California. "According to a recent rider survey, published in November [2009], 75% of bus riders have cell phones and 64% have text-enabled cell phones" (*42*). This fact and saving a considerable amount in call center operational costs drove OCTA to the deployment. Although as of May 2010, OCTA was providing schedule information only by means of SMS, this example shows that information equity is being considered even though the primary driving force in deployment could be cost savings.

Another discussion of information equity was found in Robertson (*43*). A survey was conducted in Leeds, United Kingdom, at the end of 2008 to determine the effect(s) of the availability of travel data on mode choice. The following elements of information equity were determined as a result of the survey:

- "Data has to be reliable with consistent quality of information, and timely, i.e. up-to-the-minute."
- "Information must be comprehensive. People need to know about any problems on alternatives being considered."
- "It needs to be accessible. A digestible amount of information needs to be delivered at appropriate decision points" (*43*, p. 2).

In terms of providing accessible information, which is a component of information equity, VBB provides comprehensive traveler information for disabled and mobility-impaired persons by means of the Internet, mobile devices, and speech-based telephone (*44*). This system, called VBB-Fahrinfo (described earlier in the literature review), provides barrier-free routing. This is done by collecting information on the accessibility of vehicles, stations, and transit facilities, and combining this information with real-time information.

Second, in terms of user acceptance of mobile real-time information, several studies have been conducted. A research project published by KTH Infrastructure in 2004 assessed customers' perceptions and behavioral responses to information technology-based public transport information (*45*). This research examined behavioral changes resulting from the use of IT-based applications including real-time information on mobile devices. The paper describes user response to public transport information by means of telephone, mobile devices, the Internet, and at-stop displays. Several examples of providing real-time information by means of SMS and wireless application protocol (WAP) in Europe showed that, for the most part, mobile technology was accepted, and that there were changes in travel behavior based on the use of the information provided on mobile devices:

> The success of mobile devices for travel information depends on technology and user-friendliness. Once the resistance to using the new technology is overcome through exposure and familiarity—by means of for example participation in a field test—acceptance of travel information delivered by means of mobile devices rises to a high level when the technology is applied to various interfaces and media.
>
> The possibility of being able to receive travel information by means of mobile devices shifted the point in time that information requests were made from pre-trip to on-trip. That most of the enquiries concerned journeys starting within 30 minutes showed that most of the enquiries were done with the intention of using the PT [public transport] alternative. Commuters or frequent travellers on a route greatly appreciate service-disruption information available through their mobile devices.
>
> There are some important psychological aspects to receiving more personalized, and up-to-date information. Owning a mobile device and knowing that the information service provides constant access to up-to-date information about the traffic situation made respondents feel more secure. It was shown that the information displayed on mobile devices shortens the perceived waiting time, and made participants feel more secure. Furthermore, the availability of the information service makes people feel better informed about the PT system. Feeling informed is also usually accompanied by an increased sense of "being in control," which can be seen as a positive.
>
> Some indications were found that up to 10% of people receiving PT travel information via mobile devices could be influenced in their choice of transport mode. Psychological factors, though they cannot be readily quantified, are nonetheless very important—evident in expressions such as "feeling informed about the actual situation means having control"—and contribute to a more attractive image of PT in general (*45*, p. 10).

In Pittsburgh at Carnegie Mellon University, students developed a real-time application called My Ride for the shuttle bus services that are operated in and around campus (*46*). This system provides real-time information by means of several media, including mobile devices.

An in-person and online survey of 148 people in the Oakland corridor and downtown was conducted to "measure attitudes and perceptions in regards to public transit and technology" (*46*, p. 10). The breakdown of individuals surveyed is as follows:

- 31% resulted from a random sample of pedestrians and bus riders in the Oakland corridor and downtown;
- 35% were students, faculty, and professionals in the higher education field; and
- 34% were members of developmental, cultural, and transportation advocacy groups.

The use of SMS was most preferred by 30.2% of those surveyed, and the use of the mobile website was most preferred by 8.9%.

Third, we explored the enhancement of mobile real-time information by using innovative tools including location-based services (LBSs) and social networking. The literature describing this area is plentiful, and several of the papers on this subject are briefly presented here.

Webster Lewis describes the relationship between the use of social media and proliferation of mobile devices:

> There is an inseparable link between social media and mobile devices. As the capabilities of these devices expand, we can expect that updating social-network sites by means of mobile will continue to increase and may eventually even surpass the wired web. Social networks such as Twitter and Facebook are remarkably dependent on mobile access for the value they provide to their users. Mobile status updates are, by their very nature, timelier, more relevant and potentially more interesting to their readers. Today, every major social network offers its users a range of mobile services, from mobile web access to downloadable mobile applications. Although consumers with high-end devices may be the primary users of these mobile services, some social networks also offer a number of SMS-driven features that allow consumers to stay engaged by text, even on low-end mobile phones. This represents a big opportunity for brands to maximize their efforts and move consumers easily between their mobile and social media experiences.
>
> While social media campaigns are becoming more common, we often see that when agencies and brands begin their engagement with social networks, they act as if their entire audience is on a computer—the mobile aspects of social media are frequently neglected. And the reverse can also be said about many brands' initial mobile marketing efforts: They often neglect to effectively integrate the power of mobile social-media elements (even when these elements already exist) to further engage consumers and fans of the brand (*47*).

One example of real-time information on social networking is the case of the MTA in New York City (*48*). After a ceiling collapse in the 181st Street Station on the Number 1 subway line in New York City, New York City Transit (NYCT) opened a Twitter account to report the details of the repairs. "While some might say the level of detail was mind-numbing, the updates represented an unusual level of transparency for New York City Transit, which is often viewed as an opaque, even unfriendly, bureaucracy." Paul J. Fleuranges, Vice President for Corporate Communications at NYCT, stated, "All in all I do think it has been a success, as it allows us to provide information to customers by means of a communications platform that allows for direct contact with interested riders."

Other innovative services that are facilitated by the use of mobile devices and contribute to an agency's communications strategy are LBSs. LBSs use the customer's location (available on many mobile devices) to provide more personalized real-time information on mobile devices. Several systems that use LBSs to provide real-time transit information are described in the literature. OneBusAway, which was developed at the University of Washington, "provides real-time transit information and commuter tools for Seattle-area bus riders through a variety of interfaces, including web, phone, SMS and mobile devices" (*49*, p. 1). OneBusAway provides route maps and timetables using Web 2.0 enhancements to facilitate searches, real-time arrival information, service alert notification, and trip planning. (The term *Web 2.0* is commonly associated with web applications that facilitate interactive information sharing, interoperability, user-centered design and collaboration on the World Wide Web. A Web 2.0 site allows its users to interact with each other as contributors to the website's content, in contrast to websites where users are limited to the passive viewing of information that is provided to them. See http://en.wikipedia.org/wiki/Web_2.0.) One unique feature of OneBusAway is that mobile applications have

> the potential to integrate location sensing technologies, such as GPS and WiFi-localization, with the real-time transit information system. In the other interface modalities, much of the interaction involves trying to determine where the users currently are and what routes and stops they are interested in. With the mobile apps, the location information can make narrowing the context of interest much easier, so that relevant information can be found more quickly (*49*, p. 7).

A location-aware iPhone application was developed for OneBusAway that "leverages the localization technology in modern mobile devices to quickly provide users with real-time arrival information for nearby stops and improved context-sensitive response to their searches" (*49*, p. 13) (see Figure 13). The application indicates the direction of travel of transit vehicles for each stop on the map, which is important for distinguishing between two nearby stops on opposite sides of the street. When users click on a stop, they see the stop name and the set of routes servicing that stop, helping them further disambiguate between stops. Once users identify the correct stop, they press the blue arrow button on the stop detail to bring up real-time arrival information for that stop (see Figure 14). This localization application was evaluated after it was deployed and the evaluation yielded the following:

- Ninety-three percent of the respondents reported that they were likely to walk to a different stop based on information from the application (versus 77% who used other OneBusAway tools);
- In a comparison of "how long they took to perform a typical information lookup with the assistance of a location-aware map-based interface, a map-based interface without location information, and a text-based search tree from the existing OneBusAway mobile web interface, the location-aware map-based interface is fastest for navigating to a target stop" (*49*, pp. 17–18).

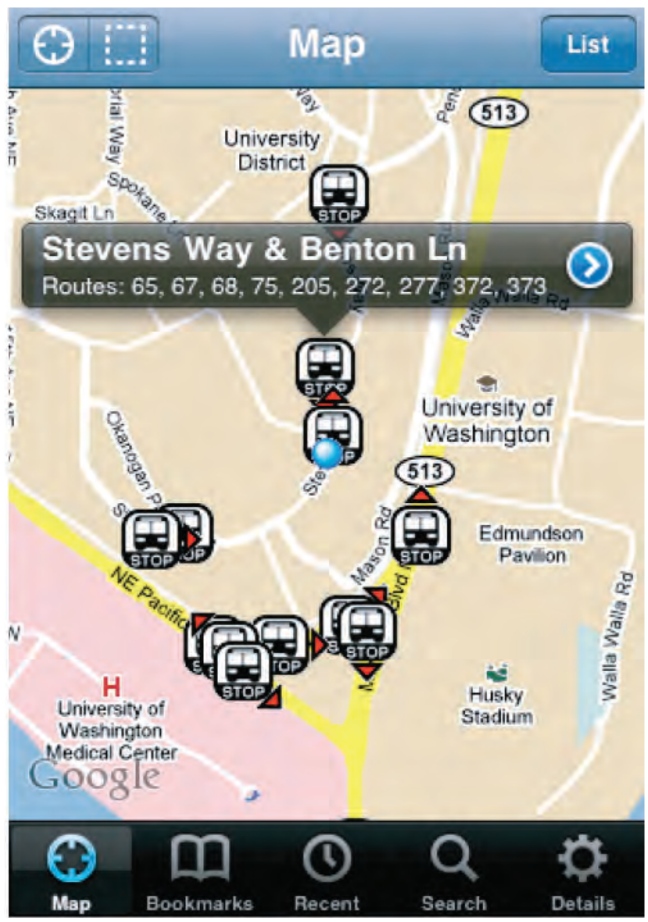


FIGURE 13 OneBusAway iPhone application. [*Source*: (*49*, p. 14).]

The literature describes several location-based real-time transit applications on mobile devices in Europe. One such system is called Seekstr (*50*). This system takes into account the following four factors: the customer's location, the customer's preferences, the customer's calendar, and the current time:

> Seekstr offers positioned, seamless, personalized and situation-aware value-added services. Since 2006, the service has been designed and implemented in a unique Swedish "Triple Helix" constellation, involving authorities [Swedish Road Administration, Stockholm Public Transport (SL)], ICT [information

and communications technologies] and consulting companies (Eniro, Idevio, Info24, Saab Security, WSP Analysis & Strategy) and a university (BTH) (*50*, p. 1).

FIGURE 14. Real-time arrival information at a particular stop. [*Source*: (*49*, p. 14).]

Figure 15 shows Seekstr's design, which includes SL, the public transport authority in Stockholm.

Another innovative application in Europe was designed to provide real-time information to visually impaired travelers (51). Because the focus of the Attraktiv Kollektiv Transport for Alle (AKTA) project is to make public transport and related information accessible for everyone, it uses mobile devices to provide real-time information to visually impaired individuals as follows:

1. The traveller gives a message by the web or SMS to the real time system about a wanted trip with the express bus from a particular bus stop at a certain time of departure, and how many minutes before (i.e., 10 minutes) arrival the real time information is wanted.

2. When the bus is approaching the bus stop, the real time information will be sent to the traveller's mobile phone in accordance with the order.

3. Additionally the passenger who has required assistance gets a SMS for instance two minutes before the bus arrives. At the same time the real time system sends a message to the driver of the bus that a person in need for assistance will enter the bus at the relevant stop.

4. As an additional service AKTA can send a SMS to the passenger two minutes before the arrival at the destination.

5. The bus driver will also receive a message two minutes before a person who wants assistance is going to leave the bus (*52*).

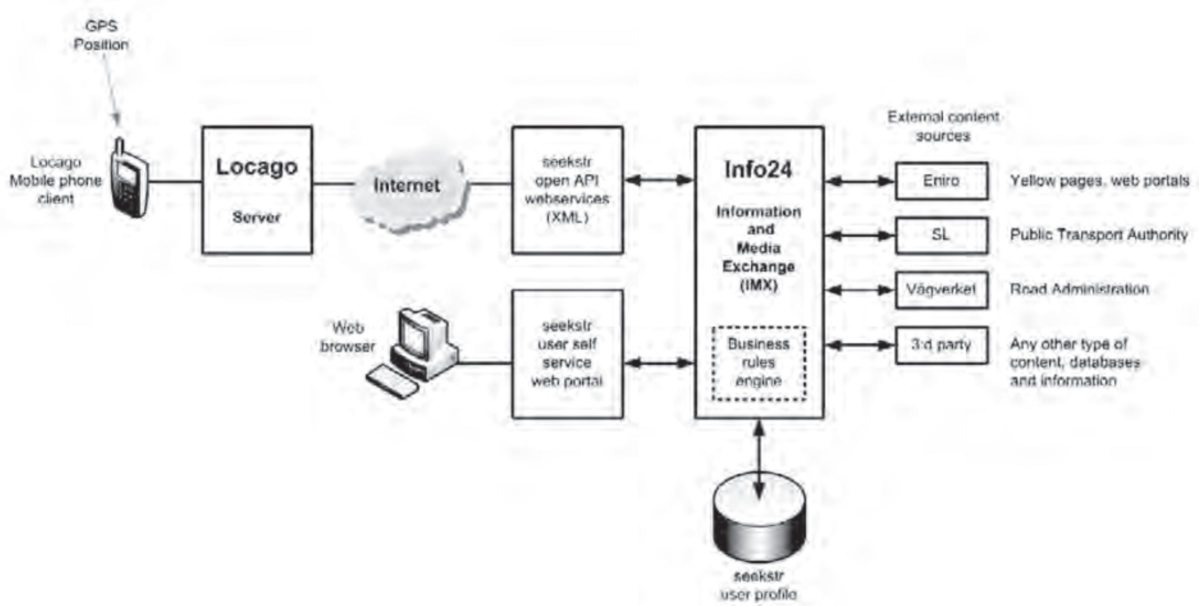


FIGURE 15 Technical design of the Smart Mobile Travel Planner Seekstr. [*Source*: (*50*, p. 3).]

The main objective of the project was to make it easier for visually impaired persons to travel with public transport. By the use of a real time system for buses and mobile telephones among the users, the visually impaired persons are ensured to get on board on the correct bus departure and off at the right bus stop (*52*).

Beyond social networking and LBSs, agencies are seriously examining their role with respect to providing information on mobile devices. At MTA NYCT, Sarah Kaufman stated that transit agencies are no longer just transportation providers—they are information providers (*53*, p. 1):

> As transit riders seek information both on-the-go and at transit facilities, the onus is upon our agencies to provide informative, yet cost-effective, tools. We are now responsible for a range of pushed real-time information to customers, a broad set of available schedules, service information and news online, and visible and audible information at subway stations and bus stops and in vehicles (*53*, p. 3).

In May 2010, MTA announced that it was opening its data to application developers:

> NYCT has massive potential for cutting-edge Web 2.0 initiatives, including a public Application Programmer Interface, which would allow web developers to create web-based software using NYCT's data; a blog, which would discuss NYCT projects and industry news; and a plethora of possible systems associated with the automated bustracking system, which is currently in development (*53*, p. 4).

Two unique applications that combine social networking and LBSs are Bay Area Rapid Transit District (BART)'s partnerships with the location-based mobile network Foursquare and junaio. These applications are described in chapter six.

Finally, an innovative unique application running on a unique mobile device was described by Joe Hughes in the San Francisco area (*54*). As shown in Figure 16, he has a Sony Ericsson MBW-150 Bluetooth watch that displays "the next few SF Muni bus arrival times for a nearby stop. The code to fetch the arrival times is running on my Droid phone, and communicating with the watch using Marcel Dopita's OpenWatch software for the Android platform" (*54*).

FIGURE 16 Sony Ericsson MBW-150 Bluetooth watch, showing the next few SF Muni Bus arrival times for a nearby stop. [*Source*: (*54*).]

CHAPTER THREE

CHARACTERISTICS OF UNDERLYING TECHNOLOGY, MOBILE TECHNOLOGY, AND MOBILE INFORMATION

The synthesis survey covered several key characteristics of the underlying technologies that are required to generate the information disseminated on mobile devices, of the mobile devices and operating systems, and of the actual mobile messages. See Table 1 and Appendix C for a list of the 28 responding agencies (representing a 100% response rate). Before examining these characteristics, the overall annual ridership and modes operated by each respondent were noted. Annual ridership ranged from 1 million (fixed-route bus and tourist van respondent) to 101.5 million (TriMet) to 1 billion (for an international respondent—National Rail in the United Kingdom).

Total annual ridership for each agency and the change in ridership for each responding agency between 2005 and 2010 are shown in Appendix D, Table D1.

UNDERLYING TECHNOLOGY AND REAL-TIME MOBILE MESSAGE TYPES

Table 2 shows the types of underlying technology being used.

The survey respondents report a wide variation in the types of real-time information and the frequency with which it is updated, as shown in Table 3. In terms of the types of real-time information, the most prevalent information that is updated on an ongoing basis is next vehicle arrival/departure prediction time, followed by information on planned detours, display/announcement of the current route and destination, identification of service disruptions, and schedule information during special events. As expected, the most prevalent information that is updated based on a specific threshold or time period is next vehicle arrival/departure prediction time. The next most prevalent information updated with this frequency is identification of service disruptions and display/announcement of the current route and destination. Finally, the most prevalent information updated when requested by customers (on demand) is identification of service disruptions, followed by next vehicle arrival/departure prediction time and information on planned detours. Although these results are not unexpected, it is interesting to note that only one type of real-time information is updated when the dissemination media are not functioning (identification of service disruptions), and none of the respondents provide real-time parking information.

TABLE 1
AGENCIES THAT RESPONDED TO QUESTIONNAIRE

Agency Name	Abbreviation	City
AC Transit	AC Transit	Oakland, CA
Afifi Group	Afifi	Nazareth, Israel
Bay Area Rapid Transit District	BART	Oakland, CA
Carris	Carris	Lisbon, Portugal
Central Ohio Transit Authority	COTA	Columbus, OH
Chapel Hill Transit	CHT	Chapel Hill, NC
CityBus	CityBus	Lafayette, IN
Fresno Area Express	FAX	Fresno, CA
Greater Bridgeport Transit Authority	GBTA	Bridgeport, CT
Kansas City Area Transportation Authority	KCATA	Kansas City, MO
Metropolitan Atlanta Rapid Transit Authority	MARTA	Atlanta, GA
METRO Transit	METRO	Oklahoma City, OK
Metropolitan Transportation Commission	MTC	Oakland, CA
MTA Metro–North Railroad	MNCR	New York, NY
National Rail	NRail	London, UK
Pace Suburban Bus	PACE	Arlington Heights, IL
Portage Area Regional Transportation Authority	PARTA	Kent, OH
Regional Transportation Commission of Washoe County	RTC	Reno, NV
Rejseplanen A/S	RA/S	Valby, Denmark
Société de transport de Laval	STL	Laval, Québec, Canada
Sound Transit	ST	Seattle, WA
Stockholm Public Transport	SL	Stockholm, Sweden
Tampere City Public Transport	TCPT	Tampere, Finland
TheBus—Oahu Transit Services, Inc.	TheBus	Honolulu, HI
Trafikanten AS	TAS	Oslo, Norway
Trafikselskabet Movia	TMovia	Valby, Denmark
Transport for London	TfL	London, UK
TriMet	TriMet	Portland, OR

TABLE 2
UNDERLYING TECHNOLOGY USED BY SURVEY RESPONDENTS

Technology	No. of Respondents
Automatic vehicle location (AVL)	23
Alert subscription system	13
Near-field communication (NFC) capability	2
Mobile tagging software (e.g., Microsoft Tag, Semacode, 2D/3D barcodes)	3
Computer-aided dispatch (CAD)	18
Schedule adherence functionality	13
Real-time arrival prediction software	25
On-board next stop announcements (visual)	19
On-board next stop announcements (audio)	21
On-board driver voice communication system	15
On-board data communication system	11
Real-time map display at stop/station	2
Two-way messaging capability (e.g., using short message service (SMS) [text messaging]	16
Light-emitting diode (LED)	9
How many with audio capability (e.g., using a push-button or infrared device to "read" DMS display)?	1
Liquid crystal display (LCD)	3
How many with audio capability?	0
Other: Please specify.	1
How many "other" with audio capability?	0

One aspect of this synthesis was to determine the use of mobile devices as dissemination media versus other known channels. As shown in Table 4, mobile dissemination media, specifically mobile web/Internet, smartphone applications, two-way SMS, mobile tagging, and near-field communication, were the most prevalent for the survey respondents. As expected, the Internet accessed by a personal computer was the next most prevalent way of disseminating real-time information, followed by DMSs and interactive voice response (IVR). These results reflect not only that this synthesis is focused on information provided on mobile devices, but that agencies are moving away from DMSs, which are more costly for dissemination owing to their operations (e.g., power and communication) and maintenance requirements. It is interesting to note that several agencies reported using mobile tagging technology, which is a relatively new mobile technology. The use of mobile websites by several agencies is shown in Figures 17 through 21.

MOBILE TECHNOLOGY

The survey covered several aspects of mobile technology, including the reasons for providing real-time information on mobile devices, the types of mobile services provided, and whether or not agencies partnered with mobile telephone providers to provide information. First, the survey results indicated that 17 of the 28 respondents decided to deploy real-time transit information on mobile devices to augment providing real-time information by means of

TABLE 3
FREQUENCY OF REAL-TIME INFORMATION

	Real-Time Information Frequency				
Type of Real-Time Information	Update on an ongoing basis	Update when dissemination media are not functioning	Update when no information available	Update per defined threshold	When requested by customers (on-demand)
Next vehicle arrival/departure prediction time	22		3	8	8
Next vehicle arrival/departure prediction distance	6		1	2	1
Real-time vehicle location	10			4	3
Availability of information and dissemination media	8			3	2
Identification of service disruptions	15	1	2	3	9
Information on planned detours	18		1	2	8
Schedule information during special events (e.g., Boston Marathon)	15		1	2	7
Emergency information (e.g., evacuation due to fire)	14		1	2	6
Vehicles/routes available for transfer	8		1		6
Display/announcement of the current route and escalators	17		2	5	3
Real time information on availability of elevators and escalators	4		1	1	1
Number of cars on the next train	2		1	2	
Wi-Fi access points and real-time information on availability					1
Real-time parking availability					

TABLE 4
DISSEMINATION MEDIA USED TO PROVIDE REAL-TIME INFORMATION

Type of Real-Time Information	DMS	Internet accessed by PC	Mobile web/ Internet	Interactive voice response (IVR)	Smartphone applications	Two-way SMS	Subscription alerts	Mobile tagging	NFC
Next vehicle arrival/departure prediction time	19	21	21	11	13	10	12	2	2
Next vehicle arrival/departure prediction distance	4	6	5	4	3	1	3	NA	1
Real-time vehicle location	2	10	7	2	6	1	2	1	2
Availability of information and dissemination media	3	6	6	3	2	2	2	NA	1
Identification of service disruptions	10	19	17	7	9	4	10	1	1
Information on planned detours	6	19	17	4	7	4	11	1	1
Schedule information during special events (e.g., Boston Marathon)	9	18	16	8	8	4	9	1	1
Emergency information (e.g., evacuation due to fire)	7	16	12	7	6	4	9	1	1
Vehicles/routes available for transfer	3	11	9	7	5	1	2		1
Display/announcement of the current route and destination	8	8	6	4	3	1	2	1	1
Display/announcement of the current route and destination	2	3	2	1	1	1	2		1
Number of cars on the next train	2	1	1		1				1
Wi-Fi access points and real-time information on availability	2		2				1		1
Real-time parking availability									1

other dissemination media (e.g., DMSs, Internet). Second, 11 of the 28 respondents decided to deploy real-time transit information on mobile devices as a more cost-effective way of providing real-time information. This response was expected because, generally, there have been discussions in the literature and industry about using information on mobile devices as a way to curb the costs of customer service, such as call centers (*42*).

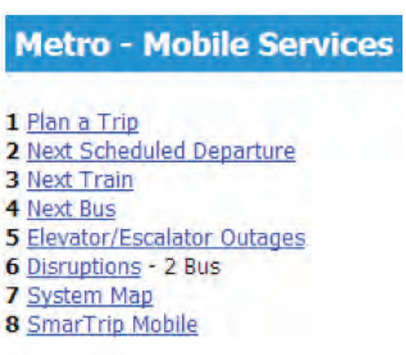


FIGURE 17 Washington Metropolitan Area Transit Authority (WMATA) mobile website (http://www.wmata.com/mobile/).

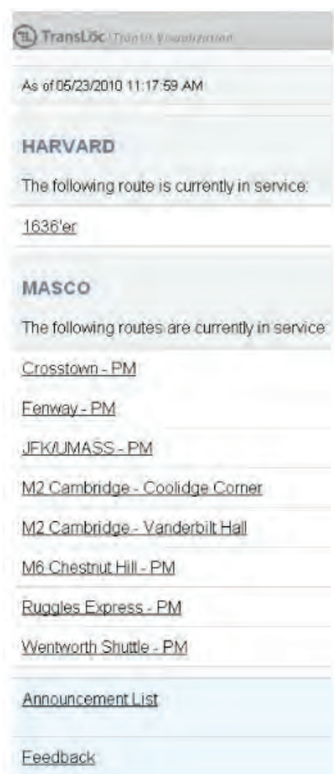


FIGURE 18 Harvard University transit visualization (http://harvard.transloc.com/m/).

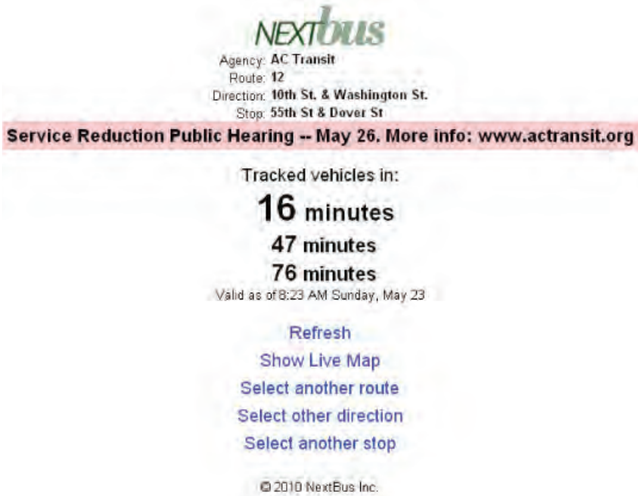


FIGURE 19 AC Transit Mobile Real-time Information (http://www.nextbus.com/wireless/miniPrediction.shtml?a=actransit&r=12&d=12_68_0&s=1002960).

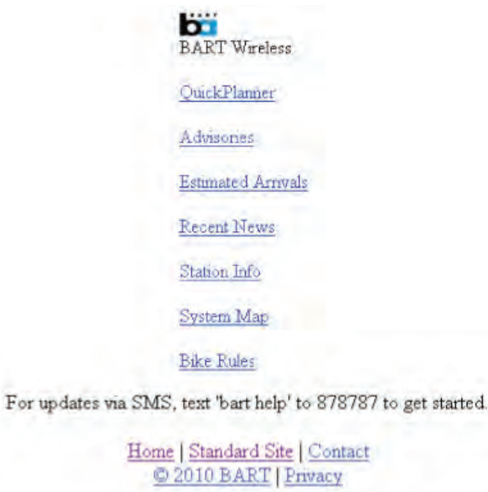


FIGURE 20 BART Mobile website (http://m.bart.gov/wireless/).

Third, only four of the 28 respondents conducted a study to determine whether or not to deploy real-time transit information on mobile devices. This would indicate that business cases or models are not being conducted or constructed to determine whether or not to provide information on mobile devices. One of the respondents, BART, conducted customer-focused research. “Initially (1999) we focused on whether there was a market and what it wanted. Ongoing research focuses on [the] awareness of BART mobile services, platform use and future purchasing decisions, data type and use cases, opportunities for third-party mobile developers using BART open data, etc.” (interview with Timothy Moore, Website Manager, BART, April 6, 2010). Another respondent, National Rail (NRail) studied the feasibility of mobile devices, and Transport for London (TfL) conducted a business case and multiple customer surveys.

FIGURE 21 Chattanooga Area Regional Transportation Authority (CARTA) mobile real-time information (http://bustracker.gocarta.org/bustime/wireless/html/home.jsp).

The survey explored the use of third parties to develop mobile applications and the guidelines governing third-party application development. It is clear from the results that the majority of agencies that have decided to provide information on mobile devices are relying on either mobile content providers or individuals to provide the information and develop the applications. Thirteen of the 28 respondents indicated that they provide real-time information (and related information) to third parties for the purposes of developing mobile applications. Of these 13, 11 agencies require that application developers register with the agency. Of these 11, 10 require that the developers agree to specific terms of use. Of these 10, five agencies set a threshold on the use of the third-party applications so that the agency’s resources are not overwhelmed.

Figure 22 depicts a typical third-party environment in which content is hosted and managed—in this case one that uses SMS as the dissemination media for information.

Figures 23 through 25 show examples of real-time information provided by means of third-party mobile applications.

These survey results indicate two key aspects of providing information on mobile devices. First, the majority of

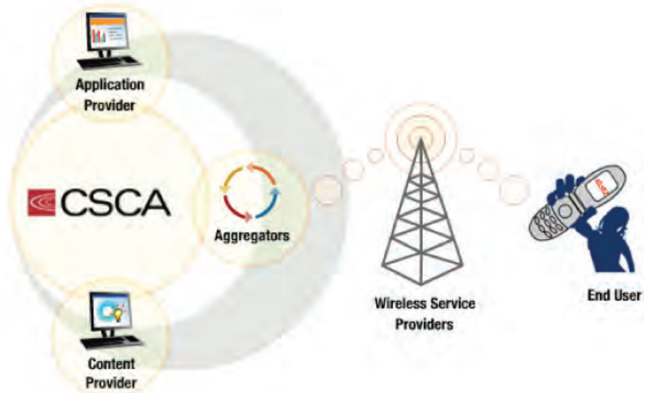


FIGURE 22 Typical mobile environment using SMS. [*Source*: (*55*).]

Transit Board™ Real Time Info

Time	Route	Board at
8 min	MAX Blue Line to Hillsboro	Pioneer Square North MAX Station
9 min	MAX Red Line to Airport	Pioneer Square South MAX Station
15 min	MAX Red Line to City Center & Beaverton TC	Pioneer Square North MAX Station
19 min	MAX Blue Line to Gresham	Pioneer Square South MAX Station
23 min	MAX Blue Line to Hillsboro	Pioneer Square North MAX Station
24 min	MAX Red Line to Airport	Pioneer Square South MAX Station
36 min	MAX Blue Line to Gresham	Pioneer Square South MAX Station

Estimates current as of 8:52AM

Transit Board™ is a trademark and service of Portland Transport. We welcome your feedback or suggestions. Route and arrival data provided by permission of TriMet.

FIGURE 23 Transit Board™ (http://tsrf.us/cgi-bin/tboard.pl?stop=8334&stop=8383).

- 4 Division/Fessenden to Gresham TC via Portland City Ctr: 09:00:13 AM (1 min)
- 4 Division/Fessenden to Gresham TC via Portland City Ctr: 09:16:48 AM (17 min)
- 16 To Vancouver Way via Rivergate: 05:32:35 AM (1233 min)
- Save To Favorites
- Map this Stop

FIGURE 24 Third-party TriMet Tracker Application (http://trimet.onmyiphone.net/arrivals?location_id=5373&route_number=4).

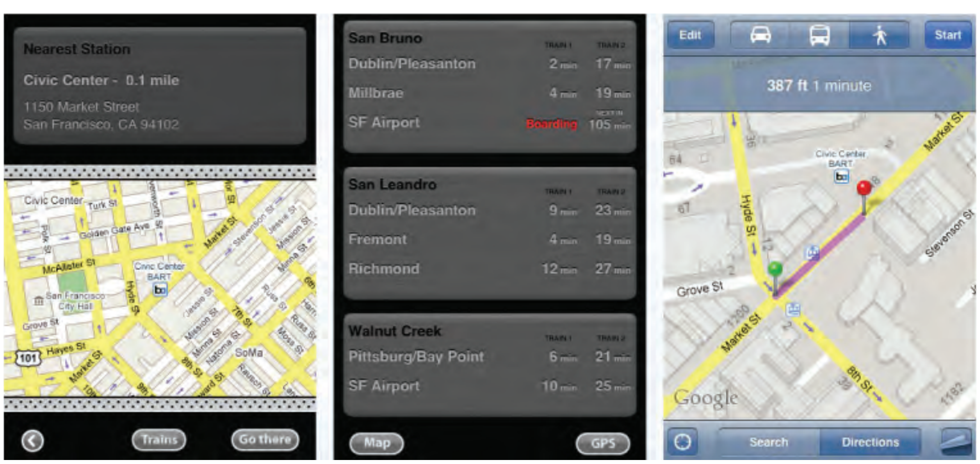


FIGURE 25 Screenshots of BART live arrivals PRO (http://itunes.apple.com/app/bart-live-arrivals-pro/id307080410?mt=8).

agencies are not developing applications for mobile devices in-house—they are relying either on individuals or companies to produce mobile applications. Second, several of the survey respondents have embraced an "open-data" approach by which individual mobile application developers can use transit agency data to develop applications. BART and TriMet have adopted this approach, which has provided considerable savings in terms of information technology staff (who would be developing the applications) and has resulted in innovative and useful applications. Their use of the open-data approach is discussed further in chapter six.

Regarding the real-time mobile services provided by the respondents, Figure 26 shows the distribution of services. Figure 27 shows the types of mobile phones on which the respondents' mobile services operate. As expected, near-file communications (NFC) phones (which enable short-range communication between the phone handset and another electronic device) are not common and are not used to a high degree to provide real-time information. Their primary use is for mobile ticketing applications, which is not covered in this report (*56*, *57*).

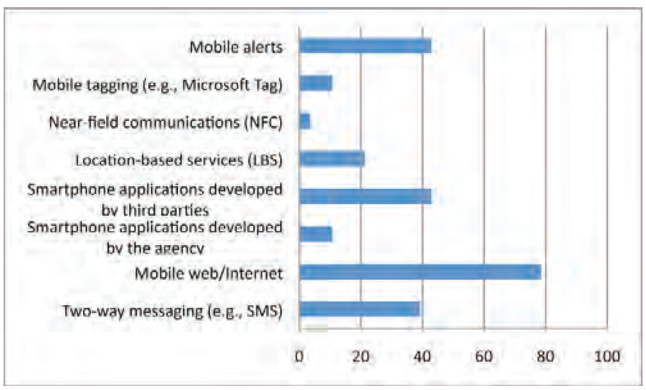


FIGURE 26 Percentage of survey respondents using mobile services to provide real-time transit information.

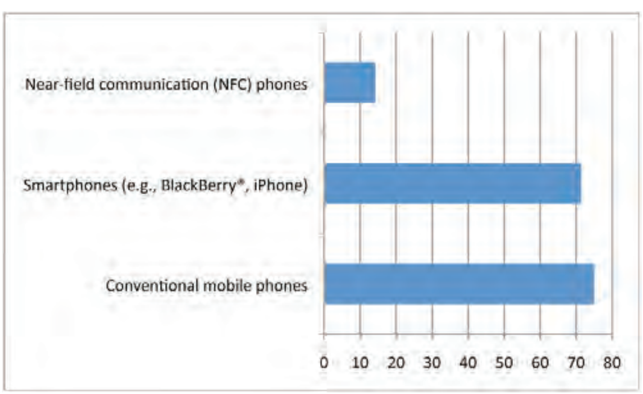


FIGURE 27 Percentage of survey respondents using mobile device types.

The mobile operating systems covered by the responding agencies, listed for information purposes only and not as an endorsement of any kind, are as follows:

- iPhone OS (14 respondents)
- Windows Mobile (13)
- Palm OS/Palm webOS (10)
- Research in Motion (10)
- Pocket PC (9)
- Symbian OS (9)
- Android (9)
- Maemo (Nokia) (7)
- Mobile Linux (6)
- bada (Samsung) (5)
- Other (4)

Seven of the 28 survey respondents noted that the software they use to provide real-time information on mobile devices automatically detects the operating system of the customers' mobile device. This feature facilitates the customers' use of mobile websites.

Only four of the 28 respondents indicated that they have partnered with mobile phone service providers. Further, only two respondents have specific contracts and/or agreements with mobile phone service providers, Internet service providers, or information service providers. This response was expected, given that the majority of the respondents provide information that is independent of mobile phone carriers.

CHARACTERISTICS OF REAL-TIME INFORMATION PROVIDED ON MOBILE DEVICES

The survey and literature review provided extensive information on the characteristics of the information provided on mobile devices. First, for agencies that use SMS to provide real-time information, the formats of those types of messages are similar, given that SMS messages are limited to 160 characters (for Latin characters) [or 70 characters for other alphabets (e.g., Chinese)]. Appendix D, Table D2, shows examples of messages sent by customers to request real-time information, and Appendix D, Table D3, shows examples of the real-time information returned by means of SMS. Figures 28 and 29 show examples of how to request real-time information via SMS.

FIGURE 28 Real-time information by means of SMS for Chicago Transit Authority—Part 1 (http://www.transitchicago.com/riding_cta/how_to_guides/bustrackertext.aspx).

FIGURE 29 Real-time information by means of SMS for Chicago Transit Authority—Part 2 (http://www.transitchicago.com/riding_cta/how_to_guides/bustrackertext.aspx).

Some survey respondents provided their mobile website addresses, as shown in Table 5.

TABLE 5
RESPONDENT MOBILE WEBSITES

Agency Name	Mobile Website Address
AC Transit	http://www.nextbus.com/wireless/miniRoute.shtml?a=actransit
BART	http://m.bart.gov
Carris	http://www.carris.pt
COTA	http://classic.cota.com/realtime.asp
CityBus	http://www.gocitybus.com/myrideweb.html
MNCR	http://www.mta.info
MTC	http://m.511.org[a]
PACE	http://www.pacebus.com
RA/S	http://mobil.rejseplanen.dk
STL	http://m.stl.laval.qc.ca
SL	http://mobil.sl.se
TCPT	http://atlas.tripplanner.fi/paras/?v=pda&lang=en
TheBus	http://hea.thebus.org
TAS	http://m.trafikanten.no
TMovia	http://mobil.moviatrafik.dk
TfL	http://www.tfl.gov.uk/tfl/livetravelnews mobileservices/
TriMet	http://m.trimet.org

[a]To be deployed in the future.

Second, the survey explored the accessibility of real-time information on mobile devices. Selected responses regarding accessibility are as follows:

- BART keeps its mobile services as "platform agnostic" as possible. Its mobile website is as simple and functional as possible and it is not optimized for one mobile browser or another.
- CityBus stated that if mobile devices are capable of browsing a web page, customers will be able to receive real-time information.
- MTA Metro–North Railroad and Metropolitan Transportation Commission (MTC) use UsableNet to provide accessible formats for all types of mobile devices, independent of the platforms used.
- Rejseplanen A/S uses standard WAP or XHTML web design.
- Specific applications have been developed for the iPhone and the BlackBerry platforms for Société de transport de Laval (STL). The mobile website is accessible to most other smartphones. The SMS service is available to all cell phones.
- By releasing the TriMet data feed to third-party developers, applications have been developed for most mobile device platforms.

One aspect of accessibility that has to be taken in account is the legibility of nontext displays, such as maps. Traditional transit maps do not necessarily display well on mobile devices because of the "low processing power, limited storage, input capability and display area" (*58*).

The survey asked whether the responding agency thought that real-time information should be provided on mobile devices by means of a "pull" action (e.g., accessing a mobile website and making a selection) or a "push" action (e.g., pushing out an SMS or e-mail with real-time information when new information is available) or both. Eight agencies stated that both should be used, seven said that only pull should be used, and one said that only push should be used. The reasons a particular approach was selected include the following:

- For both push and pull:
  - "It is hard to consider push versus pull as a discrete decision. It is just part of the delivery mechanics in an array of mobile uses cases. It depends mostly upon the medium customers choose, where they are when they want to interact with the information (e.g., standing at the platform, in transit to a station or on the service), and ultimately what customers choose most when given the options."
  - "We endeavor to provide the information in as many formats as possible, especially via technologies that are accessible on the go."
  - "It depends on the actual use situation. If we are talking about commuters then a push service might be preferred, but a pull approach might be the only solution for people searching here and now."
  - "In order to meet customers' specific requirements we offered both options."

  - "A pull method with specific selections is preferred for most applications. This limits the data transmission to small specific request on demand. Some real time updates of vehicle positions on maps require a push to supply the data as conditions change."
- For pull:
  - "We believe this is what our users want."
  - "On-demand provides the customer with the latest data when requested."
  - "We don't have the services yet to push information."

The respondents used a wide variety of standards, which can be separated into two categories: transit-specific data standards and mobile formatting standards. The standards are as follows:

- Transit-specific data standards:
  - Service interface for real-time information (SIRI), which "is an [European Committee for Standardization] XML protocol to allow distributed computers to exchange real-time information about public transport services and vehicles" (http://www.kizoom.com/standards/siri/).
  - Datex II, which is the "reference for all applications requiring access to dynamic traffic and travel related information in Europe" (http://www.itsradarinternational.info/News-Events/Latest-News/Initial-release-of-DATEX-II-Version-2_0-data-exchange-specifications;-CEN-standardisation-progressing.htm, accessed May 18, 2010).
  - Identification of fixed objects in public transport (IFOPT), which "defines a model and identification principles for the main fixed objects related to public access to Public Transport (e.g., stop points, stop areas, stations, connection links, entrances, etc.)" (http://www.kizoom.com/standards/ifopt/).
  - Transmodel, which "is a reference data model for Public Transport operations developed within several European projects" (http://www.transmodel.org/en/cadre1.html, accessed May 18, 2010).
  - TransXChange, which "is the UK nationwide standard for exchanging bus schedules and related data" (http://www.dft.gov.uk/transxchange/, accessed May 18, 2010).
- Mobile formatting standards:
  - XHTML Mobile Profile, which is a subset of XHTML that supports features for mobile devices;
  - Standard hypertext transfer protocol (http), which is a set of rules for exchanging files on the Internet;
  - XML, which is a flexible text format for creating electronic documents;
  - Representational state transfer, which is an "architectural style of networked systems" (http://www.xfront.com/REST-Web-Services.html, accessed May 18, 2010);
  - JavaScript Object Notation; and
  - SMS standard.

Through the literature review, other mobile formatting standards related to providing real-time information on mobile devices include the following (*59*):

- WAP,
- Wireless markup language,
- WAP cascading style sheet,
- User agent profile,
- Wireless transport layer security, and
- Wireless identity module.

Finally, it is critical that the real-time information provided on mobile devices be reliable and accurate; therefore, one element of the survey covered these topics. The difference between reliability and accuracy is that reliability is the ability of a system to perform its functions consistently and without failure, and accuracy is closeness to fact. In terms of reliability, respondents stated the following:

- Monitoring is conducted at 5-min intervals; there are quarterly field verifications and log checks. Given limited quality assurance/quality control resources, customer feedback is also used.
- The agency relies on the real-time application service provider (ASP) to ensure reliability.
- System reliability measurements are taken each month based on the availability (e.g., up-time) of the major systems. Depending on how well the system scores, contract language allows the agency to monetarily penalize the contractor to up to $10,000 per month.
- In a regional context, one respondent depends on the public transit authorities that provide the real-time information.
- All real-time information originates from the same source, which is monitored continuously by customer service personnel. Also, various real-time and weekly reporting tools are used to monitor the system.
- Validation is conducted throughout the data collection process.
- A few respondents indicated that they do not monitor system reliability.

In terms of monitoring accuracy, agencies indicated the following:

- IT has built logic into the application to monitor accuracy.
- As of April 2010, one regional agency respondent is in the process of defining its performance monitoring procedures. The process will include comparing information received by the mobile device to ground truth of what the user is experiencing. This respondent will also work with each agency to explore its performance monitoring process.

- Agencies use experience data (how much time it takes for the bus to go from one stop to the next) for routes at different times during different day types.
- Agencies make historical comparison of predictions with data collected through the AVL system.
- Agencies rely on the real-time ASP to ensure accuracy.

CHAPTER FOUR

RESOURCE REQUIREMENTS

Responses to the questionnaire regarding the costs of providing real-time information on mobile devices yielded limited information. Unfortunately, few respondents provided costs, indicating that the actual costs of providing real-time information are not well known. Three respondents did provide information regarding the cost to the customer to receive one SMS message: Carris charges €0.30, STL charges $0.15 Canadian dollars, and Trafikanten AS charges 3 Norwegian krone. Through a brief Internet search, the cost of receiving one SMS was obtained for additional agencies, as follows:

- For many customers, receiving and sending SMS messages are included in their monthly calling plan. For example, as of May 2010, Verizon Wireless and T-Mobile offered unlimited messaging as an add-on to a monthly voice plan for mobile devices (e.g., $20 per month for Verizon Wireless and $10 per month for T-Mobile in addition to the monthly voice charge).
- For many customers, access to the mobile Internet can be included in their monthly calling plan by having a data plan (e.g., unlimited access to the mobile Internet, mobile e-mail, and data downloading). For example, as of May 2010, Verizon Wireless offered an unlimited data plan for $29.99 per month or 25 megabytes of data for $9.99 per month.
- Dublin Bus charges €0.30 per message.
- Irish Rail charges €0.30 per message.
- Metlink in Melbourne, Australia, charges $0.55 Australian dollars per message.
- Singapore Public Transport charges $0.30 Singapore dollars.
- Leeds (UK) Traveler Information charges 25 pence per premium rate response text for SMS.

One hidden cost of providing real-time information through SMS is the cost associated with obtaining a CSC. An agency must establish an account with the CSCA and apply for a specific CSC. Then “registering and leasing a CSC costs $1,000 per month for each ‘Selected CSC’ (which could be numbers that match the agency’s name) and $500 per month for each ‘Random CSC.’ A CSC may be leased for three, six, or 12 month terms” (*60*).

To determine the labor required to support providing real-time information on mobile devices, the survey explored the departments involved in deployment. As Figure 30 shows, the IT department was most often responsible for the deployment of mobile real-time information, with customer service and marketing/communication as the next departments responsible for deployment.

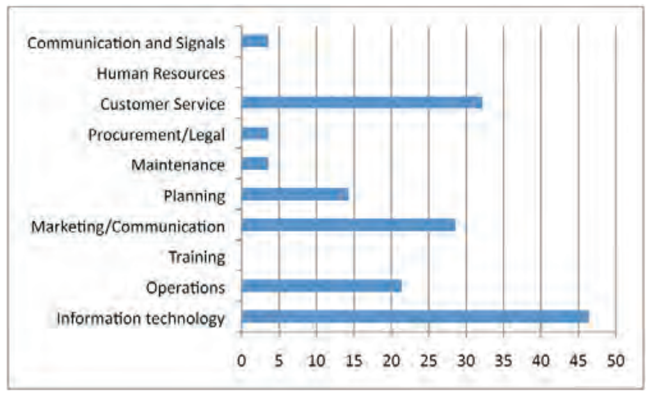


FIGURE 30 Percentage of survey respondents in which agency departments involved in deployment of mobile real-time information.

There was only one response to the question regarding the training requirements for each department/staff involved in the deployment and use of mobile technology to provide real-time information. This indicates that agencies deploying this technology do not understand the training requirements well.

When asked about the labor hours spent by each department/staff involved in the deployment and use of mobile technology to provide real-time information, only four respondents offered an estimate, as shown in Table 6.

TABLE 6
NUMBER OF LABOR HOURS PER MONTH PER AGENCY DEPARTMENT

Agency Name	Number of Labor Hours per Month
AC Transit	• Marketing/Communication—5 • Planning—5 • Customer Service—5
MTC	• Operations—30
STL	• Information Technology—4 • Operations—4 • Marketing/Communication—40 • Customer Service—80
TMovia	• Information Technology—200 • Marketing/Communication—320

Providing information on mobile devices has the potential to reduce the need for printed materials, thus saving the cost of printing and distributing these materials. For example, TriMet has drastically reduced the number of printed timetables as part of its overall strategy to move toward a paperless environment. However, agencies need to understand the gaps in information provided by means of nonprinted materials to ensure that a reduction in printed materials does not result in a lack of customer information.

CHAPTER FIVE

CONTRIBUTION OF MOBILE MESSAGING TO AGENCY COMMUNICATIONS STRATEGY

One hypothesis considered as part of this synthesis was that providing mobile real-time information contributes to an agency's overall communications strategy. This is based on reviewing numerous agency customer information strategies, such as those prepared for the MBTA (*61*) and several agencies in the United Kingdom, and on discussing the subject with the case study interviewees (see chapter six for the case studies).

In this section, the contribution of mobile real-time information is described in several ways. First, whether or not respondents have a communications strategy is mentioned, along with whether or not providing information on mobile devices is part of that strategy. Second, the responses regarding "information equity" are presented. Third, using mobile information to attract "choice" riders is described. Fourth, whether or not the deployment of real-time transit information on mobile devices resulted in an increase in ridership is discussed. Finally, there is a discussion of the potential of generating revenue through real-time information on mobile devices.

Twelve survey respondents stated that they have a communications strategy, and of those 12, eight stated that providing real-time information by means of mobile devices is part of that strategy. This indicates the importance that many agencies place on the use of mobile devices as a way to disseminate customer information.

Eight of the respondents said that they consider "information equity" when choosing specific media/channels for the dissemination of real-time information. Here, information equity means providing real-time information through at least two dissemination media in both audio and visual formats. For two of the four agencies that said that they did not consider information equity, the factors they used in choosing specific dissemination media/channels were the popularity of the media, the numbers used/sold, cost, demand, and political pressures.

The MBTA's customer information strategy specifically addresses the issue of information equity as follows:

> Real-time information will be provided for every station and stop via at least two dissemination media/channels and shall be delivered using both visual and audio formats. Information available at the station/stop will be provided via other media (e.g., IVR, website, SMS). The implementation of information in more than one medium/channel will be completed using a phased approach for all MBTA station/stops (*61*).

Further, a comprehensive customer information matrix developed as part of the strategy identified the various stages in a typical travel chain of an MBTA customer, type of information desired at each stage of travel, and the list of the dissemination media/channels that the customer could use to obtain each type of real-time information when needed. The potential channels in the matrix include the Internet (including the mobile web), customer support services, IVR, SMS, and alerts (currently provided through e-mail).

Thirteen of the 28 respondents stated that they consider providing real-time information on mobile devices as a way to attract "choice" riders. As a follow-up to this idea, the survey asked whether an increase in ridership resulted from the deployment of real-time information on mobile devices. Only four of the respondents claimed an increase in ridership, but no specific percentages were provided to back up these responses.

Seven of the respondents developed a marketing campaign specifically about the use of mobile devices to obtain transit information. Selected marketing material available on the Internet from a variety of public transit agencies is shown in Figures 31 through 36.

Agencies' viewpoints regarding pursuing advertising revenue though mobile content varied. One agency stated that "advocate[s] exploiting such channels have no desire (or understanding) of commercial opportunities. The complexity of facilitating such approaches under Official Journal of the European Union (OJEU) rules is also difficult and so easy often used as an excuse not to build and exploit such mechanisms." Another agency stated that it is open to considering ad-based revenue, but to date, it has not seen any successful applications. It would most likely never provide advertising space where it would not have control over the services being advertised. This is because the agency has concerns about certain services that might want to use its space. It would most likely try to arrange a partnership with one or two services that would use its ad space.

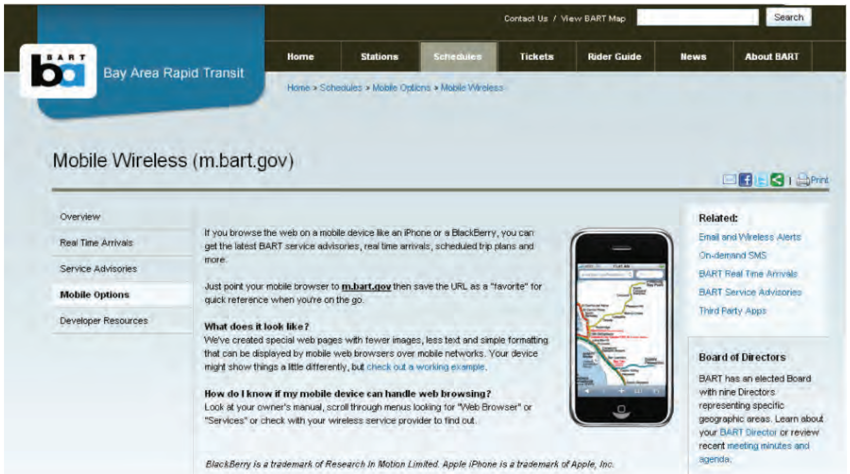


FIGURE 31 BART mobile wireless. [*Source*: (*62*).]

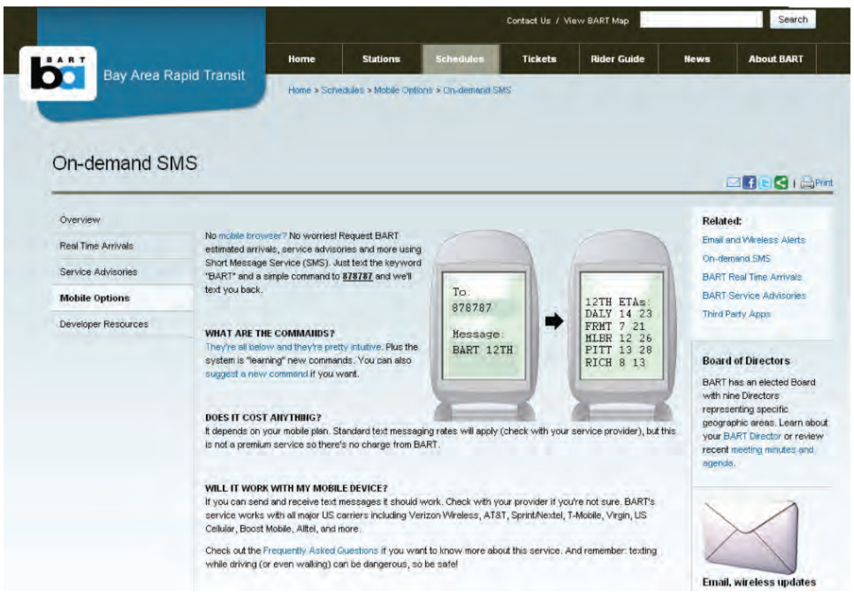


FIGURE 32 BART SMS information. [*Source*: (*63*).]

FIGURE 33 Régie Autonome des Transports Parisiens (RATP) mobile services. [*Source*: (*64*).]

FIGURE 34. Quad Cities MetroLINK. [*Source*: (*65*).]

FIGURE 35 Denver Regional Transportation District (RTD) mobile tools.

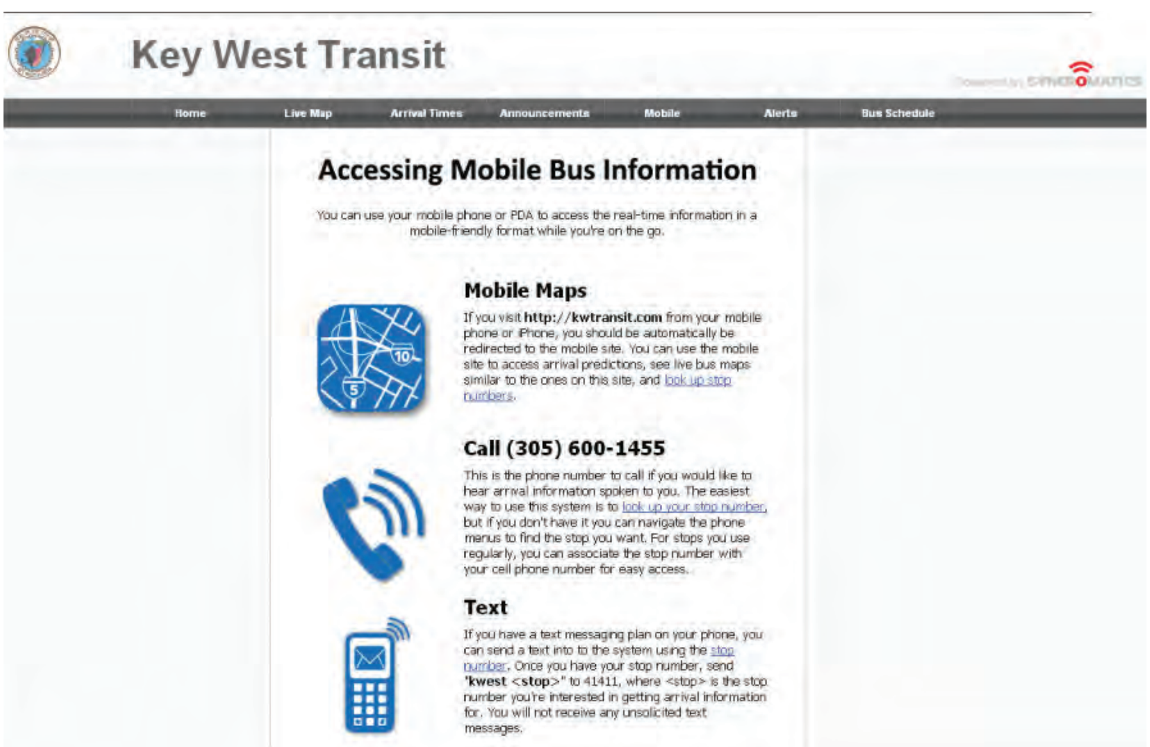


FIGURE 36 Key West Transit mobile real-time information.

Other responses include the following:

- It is currently against policy, but one agency stated that it is interested in this and is reviewing its policy. Three other agencies stated that they may explore this opportunity in the future.
- Three agencies said that they decided not to attach advertising to their messages.
- One agency said that it no longer has such a policy.

CHAPTER SIX

CASE STUDIES

Several of the transit agencies that responded to the synthesis survey were interviewed by telephone to obtain more detailed information on their provision of real-time transit information on mobile devices. The results of the interviews are presented in this section as case studies.

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

TriMet's operations department began to consider providing real-time information using DMSs at nearly 100 bus and rail stops throughout the service area several years ago. The cost associated with operating the DMSs was significant (e.g., it cost $50 per month for a telephone connection to each sign not on the agency's wide area network). DMSs display real-time information generated by TriMet's CAD/AVL system. Although customers who were surveyed liked the new DMSs, TriMet realized that deploying more DMSs at bus stops throughout the service area might not be sustainable. Further, in 2005, TriMet conducted an on-street survey of riders and determined that 70% of riders had mobile phones. In 2009 and 2010, 73 digital flat-screen displays with real-time arrival information were installed. DMSs will be programmed and designed into all future light-rail stations.

The focus of providing real-time information to customers shifted to the IT department to support placing real-time information on TriMet's website and on an IVR system. The IT department developed and tested the necessary applications, and then put the new real-time applications in place. TriMet did not advertise these new customer information services, but in the first month, the IVR application received 40,000 calls. Its usage has steadily increased since then, with 1.7 million calls received in May 2010 (compared with 8.4 million boardings).

Part of the evolution of providing real-time information at TriMet was the result of a creative developer and IT manager, who recognized that there were only a few software companies that could provide appropriate software. If one of these companies supplied the software, TriMet would have to pay an ongoing maintenance fee. TriMet estimated that these kinds of maintenance fees would have been half of the IT budget; therefore, TriMet took a lead role in the U.S. transit industry to explore open data and open source. "Open data" is considered to be "a philosophy and practice requiring that certain data are freely available to everyone, without restrictions from copyright, patents or other mechanisms of control" (*66*). According to the City-Go-Round website (*67*), currently, TriMet is one of the 107 transit agencies that provide open data. "Open source" refers to "an approach to the design, development, and distribution of software, offering practical accessibility to a software's source code" (*68*).

At the same time TriMet embraced an open-data approach and open-source philosophy, it was focusing on ensuring that its data (including real-time information) were in good shape to be used by others. Its work on using a centralized data approach, which TriMet calls a centralized enterprise data system, led to the ability to easily extract data for almost any purpose. Not only did it help in providing customer information, but it also was being used to make decisions about where to place shelters, what services to provide, and so forth. When TriMet shared its ideas regarding open data with other U.S. transit agencies at an APTA TransITech conference, it discovered that many U.S. transit agencies had data that were not in good shape.

The open-source and open-data philosophy at TriMet allowed the creation of an application that populates schedules on the Internet. This application is available to anyone for no charge. Currently, several transit properties are using it. This application provided the opportunity for other developers to add to it. "Since TriMet made its schedule and arrival data available to the public several years ago, independent programmers have created a number of useful transit tools for riders" (*69*). TriMet's website lists "some of the free and commercial applications that are available from third-party developers using TriMet's open data" (*69*). Further, TriMet was the first transit agency in the United States to be on Google Transit (Google Transit was launched in December 2005).

Just prior to making its data open, TriMet recognized that there were developers who could create innovative mobile applications at no cost to TriMet. For example, before the release of the first iPhone, a local Portland resident had an interest in knowing the next two arrivals of the bus and streetcar that he rode on a regular basis. He was able to do a "screen scrape," which meant he took data from TriMet's website and created a website for himself that displayed the arrival times for the next two buses and streetcars.

Thus, in recognizing the value of both "good" data and these developers of mobile applications, TriMet created a developer's website. Therefore, rather than requiring a large IT staff to develop such applications (and stay current with all the new mobile devices and operating systems), TriMet created an environment in which developers could use TriMet's data. TriMet's developer resources, shown in Figure 37, state that "TriMet has made resources available to software developers, to promote the use of transit and information related to transit. At this time these resources include a schedule published in the General Transit Feed Specification (GTFS) format as well as web services from TriMet's TransitTracker and trip planner systems" (*70*). Developers of TriMet mobile applications must register for an "AppID," meaning that they "acknowledge the web services Terms of Use, will be notified of upcoming changes to the API [application programming interface] and must limit the usage of the web services to 100,000 requests a day." The terms of use are shown in Figure 38.

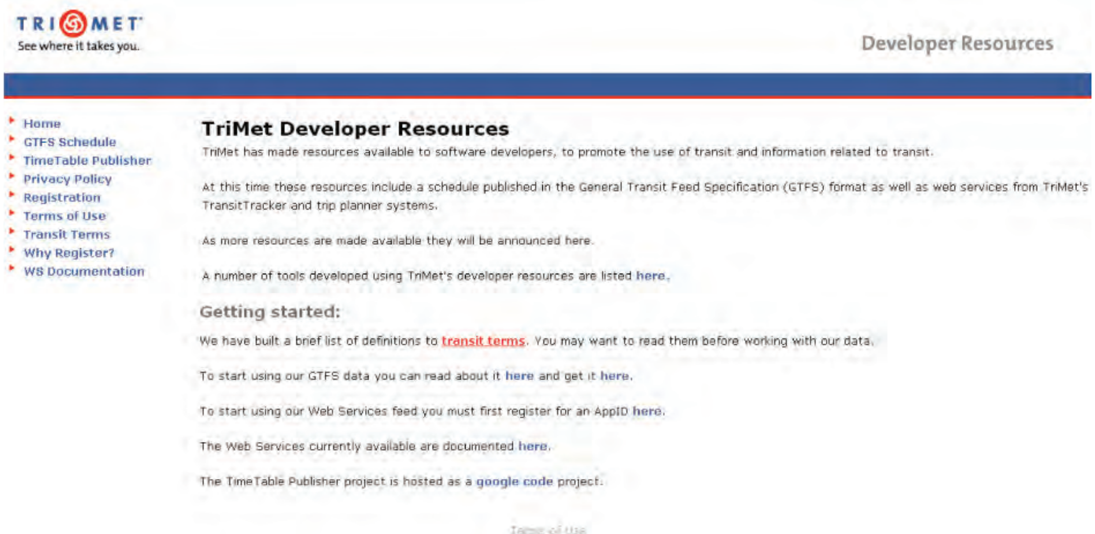
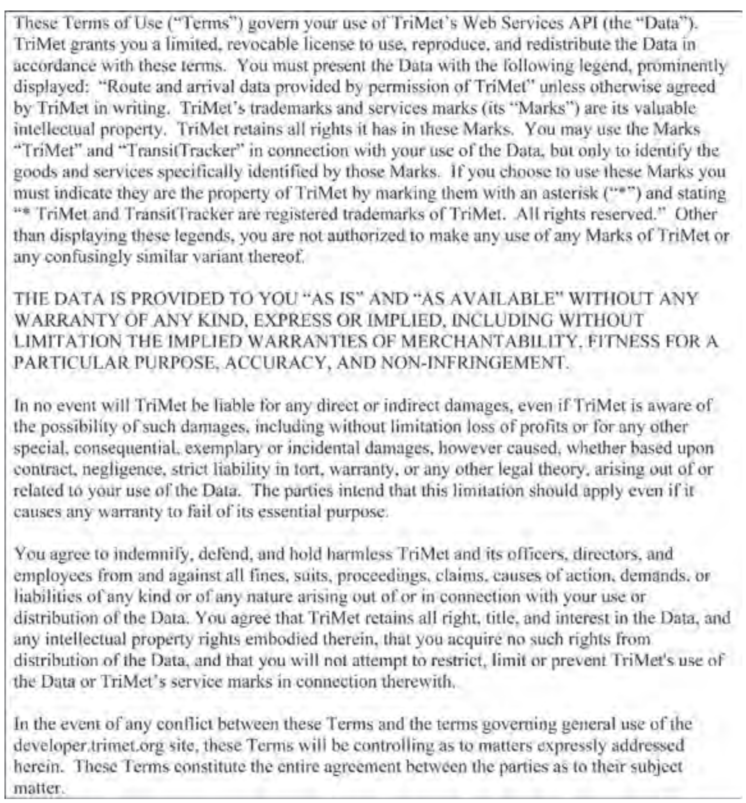


FIGURE 37 TriMet developer resources. [*Source*: (*70*, p. 14).]


These Terms of Use ("Terms") govern your use of TriMet's Web Services API (the "Data"). TriMet grants you a limited, revocable license to use, reproduce, and redistribute the Data in accordance with these terms. You must present the Data with the following legend, prominently displayed: "Route and arrival data provided by permission of TriMet" unless otherwise agreed by TriMet in writing. TriMet's trademarks and services marks (its "Marks") are its valuable intellectual property. TriMet retains all rights it has in these Marks. You may use the Marks "TriMet" and "TransitTracker" in connection with your use of the Data, but only to identify the goods and services specifically identified by those Marks. If you choose to use these Marks you must indicate they are the property of TriMet by marking them with an asterisk ("*") and stating "* TriMet and TransitTracker are registered trademarks of TriMet. All rights reserved." Other than displaying these legends, you are not authorized to make any use of any Marks of TriMet or any confusingly similar variant thereof.

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In no event will TriMet be liable for any direct or indirect damages, even if TriMet is aware of the possibility of such damages, including without limitation loss of profits or for any other special, consequential, exemplary or incidental damages, however caused, whether based upon contract, negligence, strict liability in tort, warranty, or any other legal theory, arising out of or related to your use of the Data. The parties intend that this limitation should apply even if it causes any warranty to fail of its essential purpose.

You agree to indemnify, defend, and hold harmless TriMet and its officers, directors, and employees from and against all fines, suits, proceedings, claims, causes of action, demands, or liabilities of any kind or of any nature arising out of or in connection with your use or distribution of the Data. You agree that TriMet retains all right, title, and interest in the Data, and any intellectual property rights embodied therein, that you acquire no such rights from distribution of the Data, and that you will not attempt to restrict, limit or prevent TriMet's use of the Data or TriMet's service marks in connection therewith.

In the event of any conflict between these Terms and the terms governing general use of the developer.trimet.org site, these Terms will be controlling as to matters expressly addressed herein. These Terms constitute the entire agreement between the parties as to their subject matter.

FIGURE 38 TriMet's Developer Terms of Use. [*Source*: (*71*).]

As of May 2010, there were 32 third-party applications developed for TriMet, 26 of which were for mobile devices.

TriMet provides route-based service alerts, but it is examining the possibility of providing stop-based alerts, which it believes will be more useful to customers. Further, it is looking at formatting and writing the service alerts so that they will comply with SMS restrictions (e.g., number of characters allowed).

In terms of information equity, TriMet recognizes that it has more choice riders than any other major city in the United States and that these riders have certain expectations for access to information. The choice riders examine a variety of factors when making the choice to ride transit, including whether the service goes where they need to go, whether or not they have to pay for parking, the frequency of service, the reliability of the service, the amenities available at the stop or station, and the customer information available. In addition, younger riders want to use text messaging to obtain information about transit, but text messaging has a cost to both TriMet and the customer. However, on August 16, 2010, TriMet (working with a contractor) introduced a text message service (called TransitTracker by Text) that provides real-time information by means of SMS. As of September 17, 2010, TriMet had received 35,000 texts. This service is supported by advertising, keeping it free to the customer (except for the carrier's standard text messaging/data rates, if applicable). TriMet provides real-time information and trip planning on mobile phones through http://m.trimet.org (see Figure 39).

However, TriMet recognizes that its core, frequent riders are low income and often do not have mobile devices. TriMet assesses the information that the core riders need along with the point at which they need the information. In terms of pre-trip planning, TriMet still provides a call center that has 20,000 calls per month. The call center allows TriMet to produce fewer print materials and better serve low-income and older riders. In terms of information at the stop, riders are informed about the span of service rather than the schedule. The span of service rarely changes, so TriMet does not have to replace the print information at the stop as often as if the schedule were posted. Schedules are posted at high-volume boarding areas. TriMet covers all riders by providing the call center and information on the Internet (TriMet determined that many low-income riders do have access to a computer).

Overall, TriMet's philosophy is that customer information is part of its core business, not just a nice thing to do. Further, it sees providing real-time information on mobile devices as a way to maintain or increase ridership.

BAY AREA RAPID TRANSIT DISTRICT (OAKLAND, CA)

In the late 1990s and early 2000s, BART developed its own applications for the Palm operating system. At this time,

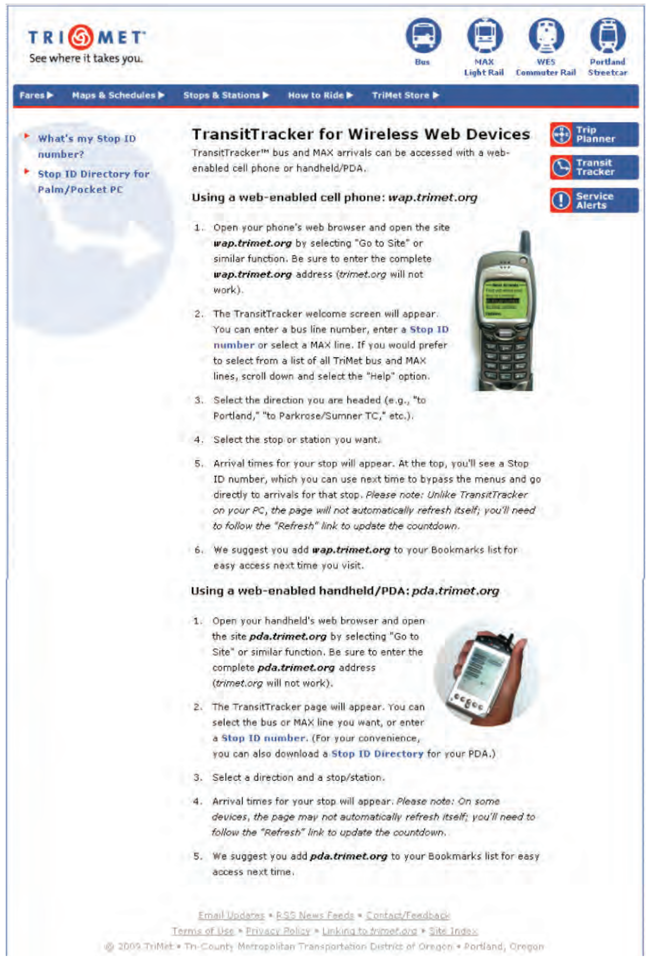

FIGURE 39 TriMet TransitTracker for wireless devices. [*Source*: (*72*).]

BART was providing transit information to MTC in a comma-separated format—there were no open data. Also, there was no support within the agency to develop and sustain additional mobile applications. There was an e-mail list of 95,000 people who wanted to be notified of transit advisories. Shortly after this time, the Palm was no longer the mobile device of choice.

Since then, BART has determined that it is much more cost-effective to focus its efforts on the data, not developing mobile applications. Currently, its website is managed by two staff; it would be challenging for such a small staff to develop applications for the myriad mobile devices on the market. Further, the IT department is focused on operating and maintaining internal business systems, not the website or mobile applications. Thus, third-party application developers have access to BART's data as they are now open, and unlike TriMet, developers do not have to register. However, each developer is subject to a developer's license agreement. And if a developer wants an API validation key, it must apply for one. Figure 40 shows BART's developer website and Figure 41 shows BART's developer license agreement.

> BART has provided open data services to third party developers since 2007, which power 26 separate

applications on more than 20 platforms including Google and Google Maps, iPhone, BlackBerry, Android, Palm Pre, Mac OSX, Twitter, Facebook and more. There are more than 1,200 BART developers subscribed to [BART's] opt-in list, and some BART apps, such as iBART for iPhone, have nearly 150,000 users (*73*).

BART provides a menu of mobile options (see Figure 42) in addition to the 31 third-party applications (as of May 2010) available either free or for a small fee. The BART mobile website (see Figure 43) provides access to real-time information, as does the SMS application (see Figure 44).

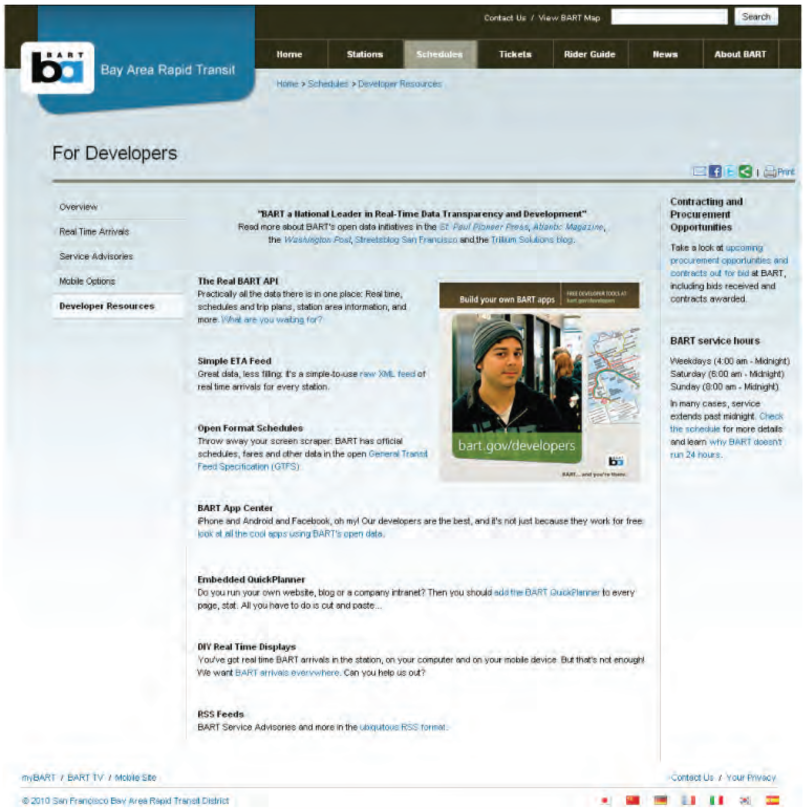

FIGURE 40 BART's developer's website.

Developer License Agreement

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FIGURE 41 BART's developer license agreement.

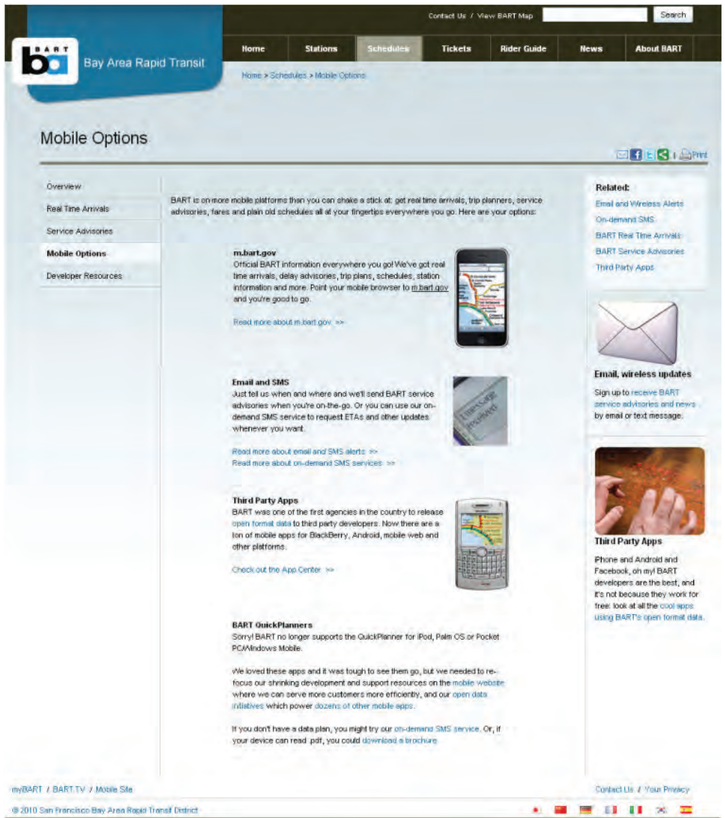

FIGURE 42 BART's mobile options.

FIGURE 43 BART mobile website.

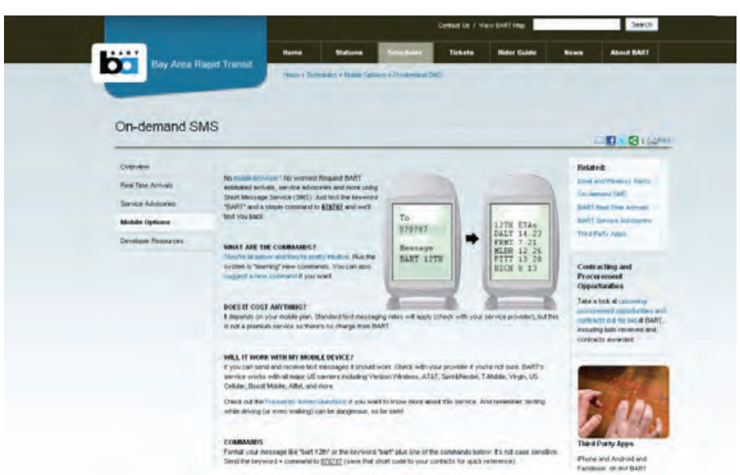

FIGURE 44 BART real-time information by means of SMS.

BART continued its foray into open data and providing real-time information on mobile devices by surveying customers in 2009 regarding the mobile "space." This survey "of BART riders who use mobile devices has found strong demand for new and existing applications. The survey was initiated by BART's website team to evaluate the market for new mobile services." BART shared the survey findings with the developer community. "Without in-house developers to create new applications, and in a time of extremely limited budget resources, it's a way for BART to foster the kind of innovation that ultimately will benefit customers. 'We're trying to give our developer network the information it needs to build the kind of applications that our customers want,' said Timothy Moore, BART website manager." BART's moving from being the primary application provider to data provider has facilitated this shift in focus.

The results of this survey, to which more than 6,500 customers responded, included the following:

- "Smartphones such as the iPhone and BlackBerry were the mobile devices most frequently used by those surveyed, followed by iPods, other media players, regular cellphones and PDAs such as Palm OS. Other devices noted by survey respondents included portable video game players such as the Sony PSP and ebook readers such as the Amazon Kindle."
- "Existing mobile applications—both those created by BART and those from third-party developers—are not widely known and have much potential for greater use."
- "Most survey respondents would prefer not to pay for trip planning or other transit applications but are willing to use ad-supported free programs."
- "More than a third of respondents plan to purchase a new mobile device within one year."

BART examined how customers using mobile devices obtain their information:

- "Printed schedules on brochures and wall signs in stations."
- "Electronic messages on overhead platform signs and station announcements, both of which contain real-time information."
- "The BART mobile website, which has real-time information."
- "Native applications that passengers download in advance to their devices, and which do not require an Internet connection."

There have been some notable successes, such as the free iBART application for iPhone developed by two college students, which has received positive customer reviews. The day the iPhone application store opened, there was a BART application. Real-time applications came just a few months after that. In addition, BART has partnered with Google to make its data available for applications developed around Google Maps, including Google Maps for Mobile (*74*).

Also, BART recognizes that there is a gap between customer needs and developer skills. BART's frame of reference is how customers look at BART versus BART's competitors. The expectation within that frame of reference is that, for example, a customer can find out when there is congestion on the road—this will influence the decision to ride BART. Further, although the developers are striving for a successful venture to support customers, the developers may not be meeting customers' needs. BART continues to be aware of all customers, recognizing that there are many different kinds of riders of (e.g., different cultures and those with cognitive and literacy issues). This awareness of customers is BART's philosophy.

BART has used social networking, primarily in response to the market in San Francisco. During regular business hours, BART supplies a Twitter feed with real-time delay advisories. As mentioned earlier in the report, BART is the first U.S. transit agency to partner with Foursquare (*75*). This partnership creates a way to push real-time information in a unique way. Foursquare users "check in" in real time to a particular BART station, affording them the opportunity to become a "mayor" of that station. Checking into specific venues allows users to earn "badges." As part of the partnership, Foursquare is offering a BART-themed badge. This type of LBS may legitimize the BART experience for a certain set of riders. In an April 2010 survey to determine the value of the Foursquare application (*76*),

> almost 70% of the respondents indicated they 'check in' when using BART and just over 40% recall recommending places near BART to Foursquare friends. Almost 20% of respondents recall making a BART trip because of a Foursquare recommendation and 14% indicated they ride BART more often because of Foursquare. Over half of respondents indicated that Foursquare has a positive impact on their BART riding experience (*76*, p. 2).

Another unique application based on BART's API is a partnership with junaio, which is an augmented reality application (*77*):

> BART and junaio have partnered to integrate transit data, such as station locations and estimated arrival times, into a BART channel on the junaio 2.0 augmented reality platform. With mobile augmented reality technology, users can see digital content such as text or graphics overlaid on real objects on their mobile phones. Junaio lets users tag photos, audio and text in the real world and leave digital "crumbs" behind at particular locations for others to explore. For example, a rider coming out of the Montgomery BART Station in San Francisco could see recommendations left by friends for restaurants or shops to try that are nearby that station. Or, simply by pointing the camera on her phone, a user could find the direction of the nearest BART station and get a list of estimated arrivals for the next several trains to her destination (*77*).

LEETRAN (LEE COUNTY/FORT MYERS, FL)

LeeTran operates service in Lee County, Florida, with 61 fixed-route vehicles, 44 demand-response vehicles, and seven vanpool vehicles. Its 18 fixed routes provide over 3 million trips per year. LeeTran's fixed-route services are divided into two categories: traditional fixed-route service and trolley resort services provided during winter and spring. LeeTran provides real-time information on mobile devices using an ASP only for its trolley resort services. It is considering expanding the current mobile information to its regular fixed-route service.

The system that provides real-time information on mobile devices consists of a GPS receiver, a GPS antenna, and a mobile data terminal (through which vehicle operators log into the system) on each of the 11 vehicles that operate the beach trolley service. The ASP's software uses data collected as the vehicles operate to estimate when each vehicle will arrive at each stop on the trolley routes. These real-time arrival time estimates are disseminated by means of SMS or the ASP's mobile website. In addition, DMSs displaying the same real-time information are located at four key stops along the trolley routes: Summerlin Square, Bowditch Park, Lynn Hall Park, and the Main Street parking lot. There is interest in expanding the number of signs to other locations within the beach zones where the trolley service operates.

Although this system is primarily for providing real-time information to customers, dispatchers use it to monitor service. Dispatchers can see where there is congestion and mitigate potential service issues by using the information generated by the system.

LeeTran pays the ASP an annual fee of $18,150 for the service. This price is based on the number of equipped vehicles and the number of DMSs in the field. In the initial deployment of the system, LeeTran considered the portion of the annual fee that went toward cellular communications (which the ASP uses to communicate vehicle location and other operational data to a central system and communicate real-time information to the DMSs) too high. Two years after the initial deployment of the system, LeeTran deployed an AVL system for its demand-response fleet and found a cellular carrier with lower prices. LeeTran negotiated with the ASP to obtain a lower cost cellular carrier, thus reducing the annual fee that LeeTran paid the ASP.

The initial deployment of this system was accomplished in 2004–2005 in partnership with the town of Fort Myers Beach, which is an island community and one of the largest destinations in Lee County. The town was interested in using public transportation as a solution to the congestion problems on the island. The town and LeeTran developed a menu of strategies to try to mitigate the beach and on-island congestion. At the same time the strategies were being developed, there was a desire to improve service headways and implement a marketing campaign to get beach and island travelers out of their cars.

The town then procured the ASP's real-time information system with the intent to pay for the capital expense, but then turned the system over to LeeTran to operate and maintain. The town of Fort Myers Beach provided the capital needed to purchase the system, and now Lee Tran is responsible for the system's operation (and pays annually for the system's operation using 100% county funds).

In the second year of operation, the real-time information system was expanded because, initially, not all the beach trolley vehicles had been equipped. Although LeeTran already had "choice" riders in the area where the beach trolley service was provided, the implementation of the real-time information system definitely attracted even more choice riders. Further, ridership on the trolley service doubled after the implementation of the system, but it is hard to isolate the real-time information as directly contributing to that increase in ridership.

There were two primary challenges in implementing this system. First, once everything in the system was installed, initial tests yielded inaccurate real-time information. Observations were made in the field of actual times and compared with the arrival times being calculated by the system. The initial deployment coincided with the winter high tourist season, which was when there were high levels of traffic congestion on the island. LeeTran worked with the ASP to solve the problem, which was done by eliminating the system's use of timetables. During the height of the tourist season (winter and early spring), the system uses vehicle location and speed to compute the arrival times at each stop, rather than using the schedule to calculate "schedule adherence" and subsequently calculate arrival times. This solution has been employed ever since it was developed—at nonpeak times of the year, the system goes back to calculating schedule adherence to estimate arrival times.

Second, initially, it was challenging for customers to use mobile devices to obtain the real-time information. This was because tourists were often not familiar with the actual stop from which they wanted to use the trolley service. LeeTran eliminated that problem by adding a four-digit number to each bus stop sign so that customers could identify by number the stop for which they were obtaining real-time information. Further, several of the resorts began publishing the stop number on their check-in literature; as soon as travelers checked into the hotel, they would know immediately which stop was closest to the hotel and the number of that stop.

Ongoing operations and maintenance of the system are the responsibility of the principal planner for LeeTran, with the marketing division, service planners, and maintenance staff responsible for specific aspects of the system, such as schedule changes (which then have to be input into the system). LeeTran staff observe the system in the field on a spot-check basis to determine the system's accuracy and reliability, and input is provided also by customers who use the system. No one is regularly assigned to perform the system spot checks.

TRANSPORT FOR LONDON (LONDON, UNITED KINGDOM)

TfL's approach to providing real-time information on mobile devices was different from those described in the TriMet and BART case studies up until June 2010. Although TriMet and BART embrace open data and open source, TfL did not officially release its data to the public. (Some data were made available to the public but required that developers obtain permission to use the data.) Prior to June 2010, real-time information on mobile devices was limited to travel alerts, which could be received through e-mail or SMS. Alerts are based on incident information that is entered into the system in the respective control room where the incident is being managed. The same information is available on the TfL and London Underground websites (http://www.tfl.gov.uk/ and http://www.tfl.gov.uk/modalpages/2625.aspx). "Once an incident is listed, it's available to the public over the web and mobile internet (WAP) in a few seconds" (*78*). SMS alerts are limited to two per day because "Mobile operators charge us [TfL] for every message that we send, and this limit is imposed to keep everyone's costs down" (*79*). TfL provides other mobile services, such as trip planning (through SMS or mobile web), live travel news by means of mobile web, timetables, and other information such as congestion charging.

In June 2010, TfL opened much of its data to the public. Initially, "information on planned weekend Tube works, the location of stations, licensed taxi operators, Oyster card top-up points and piers on the River Thames" (*80*) was provided to developers. As of September 2010, the following types of public transport data were available on London's DataStore (http://data.london.gov.uk/), which was established by the Greater London Authority (GLA) to provide access to data held and generated by the GLA and other public sector organizations in London:

- TfL station locations,
- TfL timetable listings,
- 2008 public transport accessibility levels,
- TfL cycle hire locations,
- 2009 TfL origin and destination survey,
- TfL bus stop locations and routes,
- Oyster ticket stop locations,
- London Underground signals passed at danger,
- TfL pier locations,
- River boat timetables, and
- Accessibility of London Underground stations.

TfL has stated that it "hope[s] that our announcement [of opening data in June 2010] will result in new relationships between the open data community and TfL/London's DataStore. We know from international experience that the majority of smartphone apps built on public data are focused around the reuse of public transport data" (*80*).

TfL conducted demonstrations several years ago to test the potential for introducing mobile applications using real-time information. First, from December 2006 through November 2007, TfL conducted a demonstration called Visualisation of Real-Time Transport Interchange (VORTIX). VORTIX used NFC technology embedded in 19 "touchpoint" posters in the Blackfriars London Underground station:

> When a NFC-enabled mobile phoned is placed against the smart poster, even if deep underground, it will pinpoint the exact location of the passenger and then transmit detailed information including where to go to make the next stage of the journey, how to get there, how long the transfer will take and when the next service will arrive.

This information includes all modes of transport in the vicinity of Blackfriars: Tube; National Rail; buses and river services (*81*).

VORTIX, funded by the Department for Trade and Industry, was a collaboration among TfL, Imperial College of London, and Kizoom. This was the first demonstration of providing en-route customer information using NFC technology (see Figure 45).

> Second, there were seven real-time mobile demonstration projects:
>
> The projects [were] demonstrations of potential mobile usage of a future real-time integration programme (RTIP) system that will set the vision of the programme and attempt to innovate regarding end-customer information solutions (staff and passengers). The demonstrators [were] installed to work in the RTIP data lab and scale[d] to up to 100 users (*82*).

The demonstrations were not pilot projects—they were just meant to demonstrate innovative real-time services that could be delivered by means of mobile devices. The demonstrations had four primary objectives:

- Examine the content that TfL already had and how it could be disseminated,
- Examine the form or format in which the content would be presented,
- Assess the usefulness of providing the content, and
- Determine the feasibility of developing such applications.

Several of the demonstration projects of note were

- Visual scene analysis—Underground platform congestion: The demonstration used visual scene analysis

FIGURE 45 VORTIX handset display. [*Source*: (*83*).]

techniques to gauge the level of congestion on the St. James' Park Underground station. Important features include the following:
  – Reduction in data from visual image to a low-bandwidth data item such as a count of the number of people on the platform; and
  – Employment of image recognition systems to monitor crowding.
• Converged personalized "countdown" service for mobiles: The converged personalized "countdown" service enabled passengers to view the countdown information for both buses and tubes on their mobiles/PDAs for a limited number of selected stops. For both buses and tube lines, passengers could select desired stops/stations into a personalized monitor in which they could see the real time for the selected platforms/stops. There was a limit to the number for stops/stations that each user could monitor.
• Mobile avatar solution—"Journey Angel": This project demonstrated a mobile avatar system prototype to assist the passenger throughout the trip chain: pre-trip, en route, and post-trip. The avatar can be expanded to perform all advisory/decision support actions for TfL on the mobile client including actions such as incident alerting, zone entry/exit, agreements to pay, delay alerting, and planning support. It included the dynamic monitoring of the user's location, voice rendering of text, and if there are service disruptions, the system will dynamically replan the trip.
• London mapping demonstration: Showcase of London mapping for the following purposes:
  – Superimposing TfL real-time data on a map,
  – Superimposing planned routes/route suggestions on a map,
  – Placing points of interest on a map,
  – Placing stops/stations on a map,
  – Placing user objects on a map, and
  – Placing events on a map (location/time duration).
• Converged personalized service delivery: A framework for TfL services that operates in delivering novel services to mobile, PC, and set-top box environments. The framework assisted in the seamless communication of informational, application, and presence information across users' personal wide area network, enabling all of users' devices to participate in TfL applications.

Unfortunately, owing to funding issues, none of these demonstrations was considered for full-scale deployment.

TfL's philosophy regarding providing real-time information on mobile devices can be described as follows:

• TfL has a desire to shape the data that would be used to provide information to customers using certain rules, thus influencing the behavior of the customers using the information.
• TfL considers customer relationship management as one of the most important factors in building trust among customers as well as in determining the nature of real-time information that could be provided on mobile devices.
• Information dissemination should focus on the logical design, not the technical design (suppliers/vendors are capable of providing the technical design).
• A toolkit that provides information governance to ensure that information is properly categorized, protected, managed, and disseminated is a catalyst for making it easier to provide the most timely and pertinent information to each customer.

In terms of shaping the data and customer behavior, TfL provided the following example: If there were severe congestion at Victoria Station, one of the busiest stations in London (containing National Rail, London buses and London Underground, and taxi service), it would be ideal for customers to react in a variety of different ways so that the congestion does not become more severe. To control 30% to 40% of the customers using Victoria Station, real-time information could be tailored using certain rules and personalization so that 10% of the customers would decide to continue their journey with no interruption, 10% would decide to interrupt their journey by getting off the train they are on, and 10% would decide to get coffee. This "control" of the mitigation strategies to relieve congestion requires a high degree of personalization and integration of real-time information, intimate knowledge of customers' behaviors when provided with specific information, and knowledge of how the overall system will react when real-time information is disseminated.

Currently, TfL is subject to local legislation and the original U.K. Citizen's Charter (which defines a quality of service), which promotes the release of public information and making public content available. The Citizen's Charter has been replaced with the Customer Service Excellence standard, which—

> is to encourage, enable and reward organisations that are delivering services based on a genuine understanding of the needs and preferences of their customers and communities. The foundation of this tool is the [U.K.'s] Government's Customer Service Excellence standard which tests in great depth those areas that research has indicated are a priority for customers, with particular focus on delivery, timeliness, information, professionalism and staff attitude. There is also emphasis placed on developing customer insight, understanding the user's experience and robust measurement of service satisfaction (*84*).

Indeed, the U.K. Customer Service Excellence standard and TfL's philosophy regarding information governance and customer relationship management are closely aligned. But until an information governance toolkit and funding are available to make the business case, providing real-time information by means of mobile devices will continue to be somewhat limited. In the meantime, TfL is focusing on continually strengthening its relationships with customers to ensure an appropriate level of interaction (a well-informed customer requires less manual customer service) and trust.

In terms of information equity, TfL provides elevator and escalator status updates, as well as quality of service information. There are either manual or electronic boards in each station that show the status of the whole system. Further, system status is provided on TfL's website (see Figure 46). There are onboard voice announcements as a result of the iBus project. The majority of service information is provided through nonmobile channels. The majority of information access is the use of TfL's journey planner—100 million journey plans are created every month. The journey planner is available for mobile devices, but it has somewhat limited capability. Limited service bulletins are available by means of SMS.

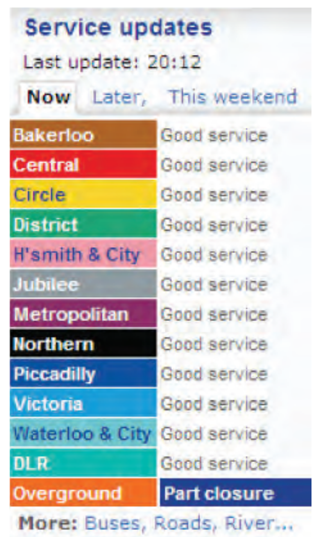

FIGURE 46 TfL service status.

CHAPTER SEVEN

FINDINGS, LESSONS LEARNED, AND CONCLUSIONS

SUMMARY OF PROJECT SCOPE

The primary purpose of this synthesis was to determine the experience with providing real-time transit information on mobile devices in the United States and abroad, 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 and deployment of real-time transit information on mobile devices using the following five dimensions:

- The underlying technology required to generate the information that will be disseminated on mobile devices. This dimension covers the required underlying software, hardware, and communications.
- The mobile technology used for information dissemination, including handset capabilities, and the specific mobile delivery channels used, such as text messaging [a.k.a short message service (SMS)], mobile Internet, and smartphone applications.
- The characteristics of the information, including message types, content, format, accessibility, and method of dissemination (push/pull); the use of standards; and the reliability and accuracy of the information.
- The resources required to successfully deploy information on mobile devices, including capital and operations and maintenance costs, agency staff requirements, customer costs, and other resources (e.g., managing an external application development program).
- The contribution of mobile messaging 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 in both audio and visual formats.

The project was conducted in the following 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 providing real-time information on mobile devices.

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

PROJECT FINDINGS

Based on the literature review, the responses to the questionnaire, and the case studies, there are four key findings of this synthesis project. First, although a limited number of transit agencies in the United States provide real-time information on mobile devices as of September 2010, there is a growing trend toward deploying this technology. As shown in the survey results, the majority of respondents decided to deploy real-time transit information on mobile devices to augment providing real-time information by means of other dissemination media [e.g., dynamic message signs (DMSs), Internet]. Also, in an era of service reductions and reduced overall budgets, transit agencies are using this type of technology to provide better customer service. Nearly 40% of the respondents indicated that they decided to deploy real-time transit information on mobile devices as a more cost-effective way of providing real-time information.

According to CTIA—The Wireless Association®—the number of mobile phone subscribers in the United States as of the end of 2009 was estimated at 285,600,000, constituting 91% of the U.S. population. This mobile device penetration together with transit agencies seeking more channels through which information can be provided to their customers have created a significant market for real-time information on mobile devices. In examining the transit agency members of APTA, approximately 45 U.S. transit agencies are providing some information on mobile devices, with approximately 15 of them providing real-time information on mobile devices.

Second, using a third party to develop real-time applications and provide real-time information on mobile devices is overwhelmingly the approach that transit agencies are taking, for a variety of reasons. There are five key elements of this study finding:

- Many agencies have limited IT and related staff, making it challenging to develop applications and manage the information dissemination in-house.
- The myriad mobile devices and operating systems, and the speed with which new devices are being released, create a demanding environment within which to develop applications and keep up with new technology.
- With mobile content being used in other industries, such as entertainment (e.g., television, radio, movies,

and music), advertising, and consumer products, there is a significant body of knowledge available to facilitate the development of useful and innovative mobile applications.
- With the large number of mobile phone and smartphone subscribers, there is a great deal of familiarity with mobile applications that are similar to real-time transit information.
- The open-data movement is having a significant effect on agencies providing real-time information on mobile devices. As seen in the survey results and case studies, several agencies that have embraced this approach do not have to expend resources on in-house development.

Thus, the use of third parties that either specialize in providing mobile content or have the capability to develop transit-specific mobile applications has been widely accepted in the United States as an effective approach to providing real-time information on mobile devices. As demonstrated by the applications described in the literature review and mentioned in the survey responses and case study interviews, agencies in the United States, for the most part, are not developing their own applications. They are relying on third parties that specialize in developing, disseminating, and managing mobile content.

Third, the costs of providing real-time information on mobile devices are not well understood and were discussed in a limited way in the literature and survey responses. The costs include not only capital, operating, and maintenance costs for the underlying systems, but costs to the customer to use mobile services [e.g., access to the mobile Internet and short message service (SMS)], costs associated with the labor to develop and manage mobile applications and third-party arrangements, and costs associated with registering common short codes (CSCs) that are used for SMS. Although the cost to customers is relatively small if mobile access to the Internet and use of SMS are already included in their monthly mobile plan, the costs borne by the agency are not completely understood.

However, many benefits are documented in the literature and mentioned in the survey responses. The most significant benefits are improved customer service, better transit agency image, potential increased ridership, and potential reduction in printed materials.

Finally, it is challenging for agencies to meet customers' already high and escalating expectations for real-time information, given the way many agencies have previously provided this type of information. Two primary factors contribute to this finding (discussed further in another subsection):

- Transitioning to providing real-time information on mobile devices from either not providing this type of information or using mobile devices for dissemination requires not only a shift in traditional transit organizations but also incorporating this type of information dissemination into strategic planning. In addition, using the information that is generated to disseminate by means of mobile devices could be helpful to parts of the organization, potentially requiring a shift in organizational roles and responsibilities. Further, efficiencies may be realized from deploying mobile information (e.g., removing fixed assets or reducing the volume of printed materials), but to date it does not appear that these are considered in strategic communications planning.
- Embracing an open-data approach, which is used often to provide information on mobile devices, requires resources to ensure that the data are accurate and have integrity. Agencies that have embraced this approach recognize that there are fewer resources required to ensure data accuracy and integrity than there are to develop mobile applications, given the large number of mobile phones and operating systems in the current market. Also, agencies may need to "filter" data that are made available for third-party application development because raw data can be misleading. Further, agencies may need to "educate" third parties (or even internal IT staff) that are not transit savvy but are developing mobile applications using agency data.

Specific findings based on the aforementioned dimensions are as follows. First, as expected, the top two underlying technologies are real-time arrival prediction software and automatic vehicle location (AVL). The top type of real-time information provided on an ongoing basis is next vehicle arrival/departure prediction time. The most common dissemination media for real-time arrival/departure information are the Internet accessed using a personal computer and the mobile web/Internet.

Second, the overwhelming reason for deploying information on mobile devices is to augment information provided by means of other media. Further, many agencies think that it is a more cost-effective way to provide real-time information. A limited number of agencies performed a study to determine whether or not to deploy real-time information on mobile devices. To keep costs reasonable and owing to the lack of resources, many agencies use third parties to develop real-time applications for mobile devices rather than develop them in-house. This trend coincides directly with agencies that have embraced an open-data approach. A majority of the mobile operating systems were covered by the agencies surveyed in this project.

Third, mobile real-time information uses SMS, push (providing information automatically when new information is available) and pull (accessing a mobile website to seek information) actions, and a wide variety of transit-specific and mobile platform standards. Further, several of the survey respondents monitor the accuracy and reliability of information disseminated by means of mobile devices.

Fourth, resource requirements for providing information on mobile devices varied widely, but there was limited information regarding the actual cost to an agency. In some cases, customers have to pay (beyond a regular fee from their mobile phone carrier to use SMS) for an SMS message with real-time information. For example, Singapore Public Transport charges $0.30 Singapore dollars to receive an SMS. In other cases, SMS messages are free to the customer (except for the regular charge to send/receive SMS messages imposed by the mobile phone carrier). For example, Tri-County Metropolitan Transportation District of Oregon (TriMet)'s SMS service is free to customers, but advertising supports it.

In terms of saving resources, providing information on mobile devices has the potential to reduce the need for printed materials. Further, although participating in an open-data program requires resources to ensure data accuracy and integrity, it appears to save significant resources if real-time information applications for mobile devices are developed by third parties (at no cost to the agency). Successful third-party applications have been developed for several agencies, including the Massachusetts Bay Transportation Authority, TriMet, Bay Area Rapid Transit District (BART), Transport for London, and New York City Transit.

Finally, information on mobile devices contributes to an agency's communications strategy, even if a formal strategy does not exist, and is considered a way to attract "choice" riders. However, some agencies consider information equity when selecting dissemination media/channels, such as mobile devices. The use of advertising to support information on mobile devices varies widely among survey respondents.

LESSONS LEARNED

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

- Issues and challenges associated with providing real-time information on mobile devices;
- Issues associated with managing a third-party development program;
- Issues associated with operating and maintaining the hardware and software necessary to generate and disseminate real-time information by means of mobile devices; and
- Overall lessons learned that would benefit transit agencies that are considering providing real-time information on mobile devices.

The following issues are associated with providing real-time information on mobile devices:

- There is still a need to provide information through other media when existing or potential customers do not have access to mobile phones or smartphones.
- From the user's perspective, the biggest issue is having to wait for a mobile page to render.
- Applications tend to be easy for the public to use, but it is harder for the agency to determine how many applications might be developed and for which platforms.
- Keeping pace with multiple mobile platforms and developing applications for them is challenging.
- Some users are not skilled on the use of mobile devices.
- General issues associated with push services are to whom you push the information and when you provide information updates.
- It can be challenging to inform customers about the accessibility and use of mobile services.
- Funding, and internal policies, culture, and change present challenges.
- When there is no mobile signal along the routes, customers will not be able to access real-time information on mobile devices.

Several of these issues are contradictory, particularly the idea that customers are both comfortable and uncomfortable with mobile devices. Further, the issue of relying on the dissemination of real-time information in areas where there is no mobile signal indicates that additional media must be used to provide real-time information.

In terms of managing a program that supports third-party development of mobile phone applications, the most significant issues are as follows:

- Ensuring the accuracy of the data provided to and data generated from third-party applications;
- Future maintenance of the program, branding issues and disagreements regarding payment for applications and owner rights;
- Lack of information governance, lack of understanding of information ownership, and lack of integrated policy, leadership, and management; and
- The perception that the application comes from an agency rather than a third party, resulting in questions directed to the agency that the agency cannot address.

In terms of operating and maintaining the hardware and software necessary to generate and disseminate real-time information through mobile devices, the following were identified as the most significant issues:

- Labor-intensive in terms of monitoring accuracy;
- Mobile service providers and the effect they may have on response time or signal availability;

- Formatting the information to be displayed on various handsets;
- AVL system up-time (servers, software, and onboard equipment);
- Number of mobile platforms and a rapid change in operating system versions;
- Maintaining interfaces from an agency's platform to the great variety of mobile solutions; and
- Cost, particularly the capital expenditure.

The overall lessons learned that would benefit transit agencies that are considering providing real-time information on mobile devices are as follows:

- An executive or board sponsor is critical to deploying this type of technology. Without this "champion," it is a challenge to obtain and maintain agency departments' interest.
- An architecture with a central source of all real-time information is important (from a regional perspective). This simplicity has been instrumental in the implementation.
- The source data (from the AVL system) must be thoroughly verified from a reliability and accuracy standpoint.
- Usage statistics to indicate customer preferences among voice, SMS, mobile web, smartphone, etc., need to be collected.
- It is more difficult to ensure that the real-time information on mobile devices is reliable than it is to provide the information on mobile devices.
- It may be useful to test the real-time information on the Internet first, and then deploy it on a mobile website.
- It is worthwhile to have only one service provider that knows the market, the new technology, and the agency's data structure, interfaces, databases, and web services.
- Exploitation of relationships with communication providers and device suppliers is critical.
- Legacy systems lacking standards or with dissimilar standards can be a problem, but a model that enables cloud deployment of such services can be helpful.
- The "one customer" approach (regardless of the mode of travel being used or the information that is being requested) with one application (or suite of applications that are rationalized) is an important driver. Users do not want to change between car parking, bus, train, subway, walking, and wayfinding applications—they prefer one application that is smart enough to respond to their needs. Further, the integration of ticketing with these applications may be a useful consideration.

CONCLUSIONS

Several conclusions can be drawn from the results of the synthesis. First, one of the most critical considerations for providing real-time information on mobile devices is the agency's ability to develop, manage, and maintain mobile applications in-house or manage third-party application development and services. If an agency develops mobile applications in-house, significant resources will be necessary to—

- Ensure that data/information from the underlying technologies are accurate and reliable (e.g., institute a monitoring program);
- Develop and maintain the necessary software that operates on all the possible mobile platforms being used by existing and potential customers;
- Consider the specific capabilities and requirements of the desired applications, including target mobile devices, desired functionality, usability, software security, and software performance;
- Use additional dissemination media to ensure information accessibility and equity. This may require even more resources because some dissemination media require specific infrastructure [e.g., DMSs, interactive voice response (IVR)]; and
- Keep current on mobile technology and update or modify applications as new technology becomes available (e.g., when Windows Mobile 7 is released, Windows Mobile 6.5 applications may not run on smartphones with Windows Mobile 7).

If an agency decides to use third parties to develop applications or host and manage the dissemination of real-time information on mobile devices, fewer resources may be necessary than if applications are developed, maintained, and managed in-house and the dissemination is managed in-house. For example, using content/application providers that specialize in software development and hosting for mobile messaging applications may require fewer resources than if development and management are done in-house. Further, "in addition to technical expertise, most application providers support content providers with expertise on the best methods and techniques for maximizing participation and success of CSC applications" (Common Short Code Administration, Find a Partner and Implement a CSC, http://www.usshortcodes.com/csc_partner.html, accessed May 20, 2010).

However, the following activities are important to remember in managing a third-party program:

- Ensure that data/information from the underlying technologies are accurate and reliable (e.g., institute a monitoring program).
- A third-party developer program for individuals must include the following:
  - Informing developers on the use of data and transit terminology;

- Making resources available to developers and set threshold for their use;
- Managing developer registration; and
- Developing and maintaining terms of use and privacy policy for developers.
- Procure the services of a mobile content/application provider that specializes in providing real-time information on mobile devices.

According to the survey results and literature review, the following companies, listed purely for informational purposes and not as endorsement of any kind from TRB or its sponsors, either host/manage mobile content or develop/manage real-time transit information applications:

• Advanced Communication and Information Systems	• ExactTarget • GovDelivery
• Affiliated Computer Services, Inc.	• Infogain
• Avego Ltd.	• Kizoom
• Syncromatics	• NextBus
• Avail Technologies	• RouteShout
• Clever Devices	• Trapeze Group

Second, there is a strong relationship between the open-data approach and the resources necessary to create useful and accurate real-time mobile applications. Two of the survey respondents that take this approach have a total of 61 mobile applications (as of May 21, 2010) that have been developed by individuals based on the agencies' open data (not all of these provide real-time information). Each agency's focus has been on ensuring that the underlying data are sound so that the resulting applications yield reliable and accurate information. In being able to focus heavily on the data rather than developing the applications, each agency has been able to save considerable resources, particularly in the IT area. It would be virtually impossible for their limited IT staffs to support and maintain applications for all the mobile phone and smartphone types and operating systems currently available.

The open-data trend in public transit is significant. ***According to City-Go-Round™, of the 780 U.S. transit agencies identified in City-Go-Round (City-Go-Round, Apps that help you get around, http://www.citygoround.org/), 107 have open data. Only seven of the 107 are providing real-time information, but the remaining 100 agencies have open data. This confirms the movement toward transit agencies making their data available to the public.

For example, one of the systems provides real-time information on a mobile phone using three screens through which the user selects the route of interest, then the direction of travel, and then the specific stop. Then, on the fourth screen, the real-time information for the specific route and stop of interest is displayed.

Third, providing real-time transit information on mobile devices is beginning to be more prevalent than the use of more traditional dissemination media, such as DMSs and IVR. Part of this trend is the result of higher customer expectations for on-demand and real-time information, transit riders' increasing ownership of mobile devices, and agencies' desire to reduce labor and operating and maintenance costs associated with more traditional media (e.g., installation, data communications to/from DMSs, power to DMSs). For example, in Great Britain, the use of virtual dissemination media, specifically SMS and wireless application protocol (WAP), has greatly increased since 2005 (the number of local authorities using SMS almost doubled between 2005 and 2008).

The higher customer expectations for immediately available and real-time information are apparent not only in the transit industry but in many other industries, such as news services, traffic information, and banking. Transit customers' increasing use of mobile technology is evidenced by statistics such as those for Orange County Transportation Authority reporting California—75% of bus riders have cell phones and 64% have text-enabled cell phones.

The need to understand better the reliability of providing real-time information on mobile devices is part of this study conclusion. Several papers state that using SMS or other mobile methods to provide real-time information may not be as reliable as necessary, owing to several factors:

- "Delivery of a single Short Message depends on the reliability of many devices. Each device in the path is highly specified, requires high performance, automatic recovery mechanisms and dependability" (Robby Benedyk, "Operational Reliability in SMS Routing," Tekelec presentation, undated, p. 3).
- "Mobile clients connect over wireless links, which are especially susceptible to overloading due to their restricted bandwidth. As they move, mobile clients can connect to different access points using various networking technologies. Therefore, continuous information delivery requires seamless handover" (Mühl et al., "Disseminating Information to Mobile Clients Using Publish-Subscribe," *IEEE Internet Computing*, p. 49).
- "The baseline reliability of SMS service is no better (and in some cases worse) than that of other communication media such as e-mail, traditional telephony and VoIP [voiceover Internet protocol]." (Meng et al., "Analysis of the Reliability of a Nationwide Short Message Service," INFOCOM 2007, 26th IEEE International Conference on Computer Communications, May 6–12, 2007, p. 9).
- For applications that require the location of the mobile device, "at low battery levels, the GPS location readings are far beyond an acceptable range" (Cevallos et al., "Feasibility Study on the Use of Personal GPS Devices in Paratransit," May 18, 2009 http://www.

fta.dot.gov/documents/TRANSPO_Feasibility_GPS_Paratransit_Final.pdf, p. 30).

- "An SMS may fail to deliver to a handset on its first delivery attempt for many reasons" ("Reliability of SMS," http://www.cardboardfish.com/support/bin/view/Main/ReliabilityOfSMS, accessed May 23, 2010).

Fourth, although using third parties to develop innovative real-time mobile applications definitely saves resources, agencies might consider that not all existing and potential customers will have mobile devices, and not all applications will satisfy the needs of all customers. Thus, several survey respondents mentioned that traditional dissemination media for real-time information that can meet the needs of individuals without mobile devices should still be assessed for deployment. For example, TriMet and BART recognize that they will not be able to cover all customers if they provided real-time information only on mobile devices. Thus, they both have active marketing programs to continually assess the information needs of their customers.

Finally, a few survey respondents mentioned personalization of information as critical to the success of providing information on mobile devices. The use of location-based services and social networking provides a certain level of personalization because customers will only receive information based on their location and interest, respectively. Further, many mobile applications allow users to customize the information they receive, such as signing up for real-time alerts for only certain routes, stops, and time periods, and saving "favorites."

SUGGESTIONS FOR FUTURE STUDY

Based on the survey results and literature review, the following areas are suggested for future study to assist agencies in determining how they might approach deploying real-time information on mobile devices. First, one issue that is critical for the success of providing real-time transit information on mobile devices is delivering the information in a timely manner. This issue might be studied from both the technical perspective (e.g., mobile network availability) and user perspective (e.g., accuracy and reliability requirements). Further, new technologies (such as 3G networks driven by Evolved High-Speed Packet Access, 4G networks, WiMax, and Long-Term Evolution) might be assessed for reliability and usability.

Much more information could be sought regarding the capital and operations and maintenance costs associated with providing real-time information on mobile devices. Now that more agencies throughout the world are deploying this technology, research into these costs conducted over the next several years might yield more data than are available currently. Further, a study could be done into the resource requirements of working with mobile content/application providers and independent application developers, as well as the resource requirements associated with moving to an open-data platform.

"Modeling" could be helpful to agencies in determining the most effective method for providing real-time information on mobile devices. A model could help an agency select the most appropriate method, taking into account the mobile phone ownership of existing riders and the population served by the agency, and resources required for each approach (e.g., open data and development of applications by individuals), in addition to factors such as whether the agency wants to attract new riders or maintain existing ridership, and several other factors that have been mentioned in this synthesis.

More in-depth information regarding the use of location-based services and social networking as mobile dissemination media might be made available to agencies. This could be in the form of a guidance document that provides information on the state of the art of location-based services to provide real-time information and examples of how specific agencies have used location-based services and social networking to provide customized real-time information. The examples could come from both the United States and abroad.

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APPENDIX A

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APPENDIX B

Survey Questionnaire

Synthesis Questionnaire
Use and Deployment of Mobile Device Technology for
Real-Time Transit Information

Date: ____________________

Name and Title of Respondent: ____________________

Transit Agency Name: ____________________

Address: ____________________

____

____

____

____

Phone Number: ____________________

Fax Number: ____________________

Respondent's E-mail Address: ____________________

Purpose of this survey: Increasingly, transportation agencies are deploying real-time transit information on mobile devices via techniques such as text messaging, mobile Internet and smartphone applications. There are several components of providing this information that include not only the underlying technology (e.g., automatic vehicle location) needed to generate the information, and capabilities of mobile telephones and smartphones, but also the types, content, and format of mobile real-time information, methods of dissemination, and how providing this information contributes to an overall customer information strategy. This survey focuses on collecting information about providing real-time information on mobile devices. Once the survey results are reviewed, key agencies that are providing real-time information using mobile technology 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!**

Transit System Characteristics:

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

- ☐ Fixed-route bus
- ☐ Paratransit
- ☐ Heavy rail/subway
- ☐ Other (please specify): ____________________
- ☐ Light rail/streetcar
- ☐ Bus rapid transit
- ☐ Commuter rail
- ☐ Ferry

2. How many total riders does your system carry on an annual basis? ____________________

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

☐ Fixed-route bus: ________________________ ☐ Light rail/streetcar: ______________

☐ Paratransit: ___________________________ ☐ Bus rapid transit: ________________

☐ Heavy rail/subway: _____________________ ☐ Commuter rail: ___________________

☐ Other (please specify):__________________ ☐ Ferry: __________________________

4. What percent change in total annual ridership has your agency experienced over the past five years (2005–2010)? ____________%

5. Does your agency have goal to increase ridership in 2010?

☐ YES ☐ NO

If YES, what is that goal? ____________%

6. Do you see providing real-time information on mobile devices as a way to maintain or increase ridership?

☐ YES ☐ NO

Underlying Technology and Real-time Mobile Message Types:

7. What underlying software, hardware, and communications systems do you utilize to generate and disseminate real-time information? Please check all that apply.

☐ Automatic vehicle location (AVL) ☐ Computer-aided dispatch (CAD)

☐ Schedule adherence functionality ☐ Real-time arrival prediction software

☐ On-board next stop announcements (visual) ☐ On-board next stop announcements (audio)

☐ Dynamic message sign (DMS) at bus stop (electronic visual sign).

Please indicate type of DMS and how many of each:

☐ Light-emitting diode (LED) ____________

How many with audio capability (e.g., using a push-button or infrared device to "read" DMS display)

____

☐ Liquid crystal display (LCD) ____________ How many with audio capability

☐ Other: Please specify: ________________ How many with audio capability _________

☐ DMS in station or on platform.

Please indicate type of DMS and how many of each:

☐ Light-emitting diode (LED) ________________ How many with audio capability (e.g., using a push-button or infrared device to "read" DMS display) ______________________________

☐ Liquid crystal display (LCD) ____________ How many with audio capability _________

☐ Other: Please specify: ________________ How many with audio capability _________

☐ On-board driver voice communication system ☐ On-board data communication system

☐ Real-time map display at stop/station ☐ Two-way messaging capability (e.g., using short message service (SMS) [text messaging])

☐ Alert subscription system ☐ Near-field communication (NFC) capability

☐ Mobile tagging software (e.g., Microsoft Tag, Semacode, 2D/3D barcodes)

☐ Other (please specify): ______________
____

8. Please note the types of real-time transit information you provide to customers and how often you provide it (check all that apply):

Type of Real-time Information	Provide? (Y/N)	Real-time Information Frequency				
		Update on an ongoing basis	Update when dissemination media is not functioning	Update when no information available	Update as per defined threshold	When requested by customers (on-demand)
Next vehicle arrival/departure prediction time						
Real-time vehicle location						
Availability of information and dissemination media						
Identification of service 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						
Display/announcement of the current route and destination						
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						
Other (please specify): _______________						

9. How is this real-time information provided to your customers?

Type of Real-time Information	Provide? (Y/N)	Dissemination Media								
		DMS	Internet accessed by PC	Mobile Web/ Internet	Interactive Voice Response (IVR)	Smartphone applications	Two-way SMS	Subscription Alerts	Mobile tagging	NFC
Next vehicle arrival/departure prediction time										
Real-time vehicle location										
Availability of information and dissemination media										
Identification of service disruptions										
Information on planned detours										
Schedule information during special events (e.g., sports event)										
Emergency information (e.g., evacuation due to fire)										
Vehicles/routes available for transfer										
Display/announcement of the current route and destination										
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										
Other (please specify): ________										

Mobile Technology:

10. Did your agency decide to deploy real-time transit information on mobile devices to augment providing real-time information via other dissemination media (e.g., DMS, Internet)?

☐ YES ☐ NO

11. Did your agency decide to deploy real-time transit information on mobile devices as a more cost-effective way of providing real-time information?

☐ YES ☐ NO

12. Did your agency conduct a study to determine whether or not to deploy real-time transit information on mobile devices?

☐ YES ☐ NO

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

____

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

☐ YES ☐ NO

If YES, do developers have to register with your agency? ____________________

☐ YES ☐ NO

If YES, do developers have to agree to specific terms of use? ____________________

☐ YES ☐ NO

If YES, please provide the terms of use. ____________________

If YES, does your agency set a threshold on the usage of the third-party applications (to not overwhelm your agency's resources)?

☐ YES ☐ NO

14. What mobile services does your agency use to provide real-time transit information? Please check all that apply.

☐ Two-way messaging (e.g., SMS)
☐ Mobile web/Internet
☐ Smartphone applications developed by the agency
☐ Smartphone applications developed by third parties
☐ Location-based services (LBS)
☐ Near-field communications (NFC)
☐ Mobile tagging (e.g., Microsoft Tag)

15. On which type of mobile phones do your agency's mobile services work?

☐ Conventional mobile phones
☐ Smartphones (e.g., BlackBerry®, iPhone)
☐ Near-field communication (NFC) phones

16. Which mobile operating system(s) do your agency's mobile services use? Please check all that apply.

☐ Windows Mobile
☐ Research in Motion (RIM)
☐ Pocket PC
☐ iPhone OS
☐ Palm OS/Palm webOS
☐ Symbian OS
☐ Mobile Linux
☐ Android
☐ bada (Samsung)
☐ Maemo (Nokia)

17. Does the software that your agency uses to provide real-time information on mobile devices automatically detect the operating system of the customer's mobile device?

☐ YES ☐ NO

18. Have you partnered with a specific mobile phone service provider(s) (e.g., VerizonWireless, Sprint, AT&T) to provide real-time information?

☐ YES ☐ NO

If YES, which service provider(s) and what is the nature of the partnership?

____

____

19. Does your agency have specific contracts and/or agreements with mobile phone service providers, Internet service providers, or information service providers? For example, Transport for London has arrangements with orange™, O_2, T-Mobile, and vodafone™ to provide a variety of mobile Internet services.

☐ YES ☐ NO

If YES, what service providers does your agency have contracts/arrangements with?

____

____

Characteristics of Real-time Transit Information Provided on Mobile Devices:

20. For real-time information provided via SMS, please provide the format of the messages sent by customers to request the information. For example, "Send **ctabus 14624 to 41411**."

____

Please translate the message(s) sent by customers to request the information. For example, "Send **ctabus 14624** to **41411**" means that the customer is requesting the next two real-time arrival times for CTA buses at stop ID 14624.

____

____

____

21. For real-time information provided via SMS, please provide the format of the messages sent from the agency back to customers. For example:

From 41411

5:07 PM

14624) Pulaski & Fullerton

53 to 31st DUE & 11 minutes

Reply S)ervice Bulletins

R)efresh

____

____

____

____

____

____

Please translate the message(s) sent by the agency to customers. For example, the above example is translated as "as of 5:07 PM, at stop 14624 (at Pulaski & Fullerton), Bus Tracker estimates that a #53 bus to 31st is **due** to arrive, and then another one should arrive in about **11 minutes**.

____

____

____

22. For additional real-time information provided via mobile services, please provide the answers to questions 19 and 20 on the additional pages provided at the end of the questionnaire.

23. For real-time information provided via the mobile Internet, please provide the mobile website address to access real-time information:

____

24. How does your agency ensure that real-time information is accessible to everyone who owns or uses a mobile device?

25. Does your agency believe that real-time information should be provided on mobile devices via a “pull” action (e.g., accessing a mobile website and making a selection) or a “push” action (e.g., pushing out an SMS or e-mail with real-time information when new information is available) or both?

☐ Pul ☐ Push ☐ Both

Why has your agency chosen this approach?

26. What standards does your agency use to provide real-time information via mobile devices?

27. How does your agency ensure the reliability of the real-time information provided via mobile devices?

28. How does your agency ensure the accuracy of the real-time information provided via mobile devices?

Required Resources:

29. What are the capital, and annual operations and maintenance costs of providing real-time information to customers?

Real-time Information Dissemination Media/ Channels and Other Cost Items	Total number of units	Total capital cost	Total annual operating and maintenance cost	Other (please specify): ______
Dynamic Message Signs (DMS):				
At transit stop/station				
On-board transit vehicle				
Internet accessed by PC				
Mobile web/Internet				
Interactive voice response (IVR) system				
Smartphone applications developed by the agency				
Subscription alert system				
Mobile tagging system				
Near-field communication (NFC) system				
Contract/agreement with wireless carrier				
Information service provider				
Mobile application software				
SMS (text) message system				
Internet-based text message system				
E-mail software				
Other hardware (please specify): ______________________				
Other software (please specify): ______________________				

30. Does your agency charge for the customer to receive an SMS from your agency?

☐ YES ☐ NO

If YES, what are the charges associated with receiving an SMS?

____

31. Does the mobile phone service provider(s) offer your agency a special pricing plan for providing real-time information on mobile devices?

☐ YES ☐ NO

If YES, please describe the pricing plan(s): ________________________________

____

____

32. Is your agency aware of the cost to customers to send an SMS message to request real-time information?

☐ YES ☐ NO

If YES, please describe the pricing plan(s):

____

____

33. Which departments/staff are involved in the deployment and use of mobile technology to provide real-time information? Please check all that apply.

☐ Information technology ☐ Planning
☐ Operations ☐ Maintenance
☐ Training ☐ Procurement/legal
☐ Marketing/communication ☐ Customer service
☐ Human resources/training ☐ Other (please specify): ______________

34. What are the training requirements for each department/staff that are involved in the deployment and use of mobile technology to provide real-time information? Please indicate the requirements in number of labor hours per month.

☐ Information technology: ______________ ☐ Planning: ______________
☐ Operations: ______________ ☐ Maintenance: ______________
☐ Training: ______________ ☐ Procurement/legal: ______________
☐ Marketing/communication: ______________ ☐ Customer service: ______________
☐ Human resources/training: ☐ Other (please specify): ______________

____

______________ hours

35. How many labor hours are spent by each department/staff that are involved in the deployment and use of mobile technology to provide real-time information? Please indicate the number of labor hours per month.

☐ Information technology: ______________ ☐ Planning: ______________
☐ Operations: ______________ ☐ Maintenance: ______________
☐ Training: ______________ ☐ Procurement/legal: ______________
☐ Marketing/communication: ______________ ☐ Customer service: ______________
☐ Human resources/training: ______________ ☐ Other (please specify): ______________

____

______________ hours

Contribution of Providing Real-time Transit Information on Mobile Devices to Agency Communications Strategy

36. Of all dissemination media that your agency uses to provide real-time information, what is the percentage of usage of each type of media? All responses should add up to 100%.

☐ DMS: ______________% ☐ Internet accessed by PC: ______________%
☐ Mobile web/Internet: ______________% ☐ Interactive voice response (IVR): ______________%
☐ Smartphone applications: ______________% ☐ Two-way messaging (e.g., SMS): ______________%
☐ Subscription alerts: ______________% ☐ Mobile tagging: ______________%
☐ NFC: ______________% ☐ Other (please specify): ______________

______________%

37. Does your agency have a Communications Strategy?

☐ YES ☐ NO

If YES, is providing real-time information via mobile devices a part of that Strategy?

☐ YES ☐ NO

38. Does your agency consider "information equity" when it chooses specific media/channels for the dissemination of real-time information? Here, information equity means providing real-time information via at least two dissemination media and in both audio and visual formats.

☐ YES ☐ NO

If NO, what factors are used in choosing specific dissemination media/channels?

____

____

____

39. Does your agency consider providing real-time information on mobile devices as a way to attract "choice" riders?

☐ YES ☐ NO

40. Did the deployment of real-time transit information on mobile devices result in an increase in ridership?

☐ YES ☐ NO

If YES, how much did ridership increase as a result of disseminating information via mobile devices? __________ %

41. If you have conducted surveys and/or focus groups to determine the usage of mobile communication among your ridership, can you provide the survey results for this Synthesis project?

☐ YES ☐ NO

42. Have you developed a marketing campaign specifically about the use of mobile devices to obtain transit information?

☐ YES ☐ NO

If YES, may we obtain copies of the marketing campaign?

43. What is your agency's opinion regarding collecting advertising revenue though mobile content? For example, is your agency interested in context-sensitive advertising based on the current location of the mobile device?

____

____

____

44. What is the one biggest problem associated with providing real-time information on mobile devices?

____

____

____

45. If your agency provides real-time information for third-party development of mobile phone applications, what is the one biggest problem associated with managing such a program?

____

____

____

46. What is the one biggest problem associated with operating and maintaining the hardware and software necessary to generate and disseminate real-time information via mobile devices?

____

____

____

47. Please describe any additional “lessons learned” that would benefit transit agencies that are considering providing real-time information on mobile devices.

____

____

____

48. Are there other agencies that you know of that we should speak to regarding “best practices” in terms of providing real-time information via mobile devices? If so, please provide contact information.

____

____

____

Please return the completed questionnaire by February 15, 2010 to:

Ms. Carol L. Schweiger

Vice President

TranSystems Corporation

38 Chauncy Street, Suite 200

Boston, MA 02111 U.S.A.

Telephone: 857-453-5511

Fax: 857-453-5451

E-mail address: clschweiger@transystems.com

We encourage you to return your completed survey to Ms. Schweiger via e-mail at clschweiger@transystems.com. If you have any questions on the survey or the project, please do not hesitate to call Ms. Schweiger. Thank you very much for your participation in this important project.

Format of Additional Real-time Information Provided on Mobile Devices:

1. For real-time information provided via SMS, please provide the format of the messages sent by customers to request the information. For example, "Send **ctabus 14624 to 41411**."

   ____

   Please translate the message(s) sent by customers to request the information. For example, "Send **ctabus 14624 to 41411**" means that the customer is requesting the next two real-time arrival times for CTA buses at stop ID 14624.

   ____

   ____

   ____

2. For real-time information provided via SMS, please provide the format of the messages sent from the agency back to customers. For example:

   From 41411

   5:07 PM

   14624) Pulaski & Fullerton

   53 to 31st DUE & 11 minutes

   Reply S)ervice Bulletins

   R)efresh

   ____

   ____

   ____

   Please translate the message(s) sent by the agency to customers. For example, the above example is translated as "as of 5:07 PM, at stop 14624 (at Pulaski & Fullerton), Bus Tracker estimates that a #53 bus to 31st is **due** to arrive, and then another one should arrive in about **11 minutes.**

   ____

   ____

   ____

APPENDIX C

List of Agencies Responding to the Survey

Transportation Planner
AC Transit
1600 Franklin Street
Oakland, CA 94612

Office Manager & PR
Afifi Group
Paul VI Street
POB 50256
Nazareth 16102
Israel

Website Manager
Bay Area Rapid Transit District (BART)
300 Lakeside Drive, 18th Floor
Oakland, CA 94612-3534

Engineer
Carris
Rua 1º de Maio, 101-103
Lisboa 472
Portugal

Public and Media Relations Manager
Central Ohio Transit Authority
3052 Jersey Drive
Columbus, OH 43222

Scheduling Coordinator
Chapel Hill Transit
6900 Millhouse Road
Chapel Hill, NC 27516

Manager of Development
CityBus
1250 Canal Road, P.O. Box 588
Lafayette, IN 47902

Transit Planning Manager
Fresno Area Express
2223 G Street
Fresno, CA 93706

Planning Officer
Greater Bridgeport Transit
One Cross Street
Bridgeport, CT 06610

Director of Marketing
Kansas City Area Transportation Authority
1200 E. 18th Street
Kansas City, MO 64108

Analyst
MARTA
2424 Piedmont Road NE
Atlanta, GA 30324

Marketing Manager
METRO Transit
300 SW 7th
Oklahoma City, OK 73109

Manager
MTA Metro–North Railroad
420 Lexington Avenue, 9th Floor
New York, NY 10017

Senior 511 Program Coordinator
MTC
101 Eighth Street
Oakland, CA 94607

Head of Online
National Rail Enquiries
40 Bernard Street, 3rd Floor
London WC1N 1BY
United Kingdom

IT Systems Administration Manager
PACE Suburban Bus
550 W. Algonquin Road
Arlington Heights, IL 60005

Manager of Operations and IT
Portage Area RTA
2000 Summit Road
Kent, OH 44240

Senior Transit Planner
Regional Transportation Commission of Washoe County
2050 Villanova Drive
Reno, NV 89502

Project Manager
Rejseplanen A/S
Gammel Køge Landevej 3
Valby 2200
Denmark

Advisor, External Communications and Customer Contact Centre Management
Société de transport de Laval
2250, avenue Francis-Hughes
Laval, Québec H7S 2C3
Canada

Communications Specialist
Sound Transit
401 S. Jackson Street
Seattle, WA 98104

Business Developer, Traffic information
Stockholm Public Transport
Linghagensgatan 100
Stockholm 105 73
Sweden

Chief Planner
Tampere City Public Transport (Authority)
POB 487
Tampere 33101
Finland

Director, Planning and Service Development
TheBus—Oahu Transit Services, Inc.
811 Middle Street
Honolulu, HI 96819

Managing Director
Trafikanten AS
Karl Johansgate 1, 6 etg
Oslo 0106
Norway

Team manager
Trafikselskabet Movia
Gammel Koege Landevej 3
IT
Valby 2500
Denmark

Programme Manager, Group Customer Services
Transport for London
Victoria Station House, 6th Floor
191 Victoria Street
London SW1E 5NE
United Kingdom

Chief Technology Officer
TriMet
4012 SE 17th Avenue
Portland, OR 97202

APPENDIX D

Additional Information

TABLE D1
TOTAL ANNUAL RIDERSHIP

Agency Name	Annual Riders
AC Transit	69,689,000
Afifi	1,000,000
BART	356,000,000
Carris	325,000,000
COTA	16,700,000
CHT	7,291,460
CityBus	4,900,000
FAX	18,250,000
GBTA	5,200,000
KCATA	15,250,000
MARTA	150,000,000
METRO	2,702,929
MNCR	70,000,000
MTC	315,000,000
NRail	1,000,000,000
PACE	35,000,000
PARTA	1,490,000
RTC	8,687,260
RA/S	NR
STL	20,330,000
ST	180,000,000
SL	672,000,000
TCPT	27,000,000
TheBus	77,000,000
TAS	250,000,000
TMovia	207,000,000
TfL	NR
TriMet	101,500,000

Note: NR = not reported.

TABLE D2

SMS SENT BY CUSTOMER TO OBTAIN REAL-TIME INFORMATION

Message Sent by Customer	Message Translation
nbus actransit broadway & 17th	Passenger is requesting the real-time information for AC Transit buses at Broadway & 17th St.
Text the keyword “bart” and a simple command to 878787. Text ‘bart help’ for a list of commands or visit http://bart.gov/sms for more details.	“bart 12th” is a request for ETAs at 12th Street BART Station. All stations have a simple, mnemonic 4-character code used elsewhere for real-time services. Other commands include “bart svc” for service advisories, “bart elev” for elevator advisories, “bart contact” for contact info. The system is also “learning” and incorporating/interpreting mistypes and full names; e.g., we understand that “bart castro valley” maps to “bart cast” as a request for ETAs at that station.
text stop-ID # to short code 25252	When stop-ID is texted, next scheduled bus for that location will be sent back to them.
Send chapelh 1602 to 41411	Real-time arrival times for CHT buses at stop ID 1602
Send 511 dep [stop id] to 368674. We are currently working on a version that can accept station names and cross-streets. Send 511 dep [station or cross-street] to 368674.	Send 511 dep [stop id] to 368674 means that the customer is requesting three predictions for every route that stops at this stop ID, where “511 dep” indicates our 511 Departure Times system.
SMS-MO: “12345 678”	12345 is the stop number (unique), 678 is the specific route (optional).
“S 6563” or “S Fyrrevej” or “S 6563 L 601” or “S Fyrrevej L 601”	Gives the next arrivals (looking two hours ahead) at stop ID 6563. The arrivals are real-time, if we have the information. Otherwise it’s the scheduled time. Same, but stop ID 6563 is substituted with the name of the stop “Fyrrevej.” The two last examples give the same information, but only show arrivals of buses on line 601.
ctabus [stopID] to 41411	Information regarding buses predicted to arrive at stopID
ctabus [stopID] rt[#] to 41411	Information regarding buses on route # to arrive at stopID

TABLE D3
SMS SENT TO CUSTOMER WITH REAL-TIME INFORMATION

Message Sent to Customer	Message Translation
r=72 s=Brdwy & 17th d=To Oklnd Amtrk 12&29m d=To Pnt Rchmnd 16&52min—rply:B)ack, 1-30) for alert or S)ave name	For route 72 at stop Broadway & 17th there is a bus at 12 and 29 min going toward Oakland Amtrak and a bus at 16 and 52 min going toward Point Richmond
(for ETA requests) 12TH ETAs - FRMT 8, 22, 37; MLBR 13, 28, 43; PITT 18, 34, 52; RICH 9, 15, 30; SFIA 6, 20, 35 (for Service Advisories requests) RECOVERING FROM A 10–12 MIN DELAY AT WOAK IN THE SAN FRANCISCO DIR TO A MEDICAL EMERGENCY. (for Elevator Advisories requests) 1 ELEV OUT OF SVC - POWL ELEV. (for Help requests) Text 'BART svc' for delays, 'BART station' for ETA commands, 'BART elev' for elevators or 'BART contact'. More at www.bart.gov/sms	(for ETA requests) 12th Street BART station has the following estimate arrivals: Fremont-bound train in 8, 22, and 37 min; Milbrae-bound train in 13, 28, and 43 min; Pittsburg/Bay Point-bound train in 18, 34, and 52 min; Richmond-bound train in 9, 15, and 30 min; San Francisco Airport-bound train in 6, 20, and 35 min. (for Service Advisories requests) BART is recovering from a 10–12-min delay at West Oakland Station in the San Francisco-bound direction due to a medical emergency. (for Elevator Advisories requests) There is one BART elevator out of service at Powell Street station. (for Help requests) Text 'BART svc' for information about BART delays. Text 'BART station' for Estimated Arrival commands. Text 'BART elev' for elevator status. Text 'BART contact' for contact information. There are even more details about how to use this service at www.bart.gov/sms.
RouteShout BUStracker: Scheduled 002 10:19 a.m.	The next route #2 bus will arrive at the N. High St. and E. Hudson St. location at 10:19 a.m.
@ 10:59am r=J s=Smith Lvl Rd @ FPG School d= To Jns Frry 26&46min	At 10:59 a.m. route = J Route Stop = Smith Level Rd at Frank Porter Graham School Direction = to Jones Ferry 26 and 46 min is the next scheduled bus.
Muni Church St. and Duboce Ave. (ID# 14006) J Inbound in 5, 12, 23 min, 22 Inbound in 5, 17, 21 min as of 4:23 p.m.	Since 511 is multi-agency, the message starts out by identifying the agency, Muni. Next the message identifies the stop name followed by its unique stop ID. Then the message states the first route and direction (J—Inbound) that stops at stop ID 14006 and includes its next three departure predictions. This is immediately followed by the second route and direction that stops at the same stop followed by its next three predictions. If there were more routes that stopped at 14006, they would also be displayed.
SMS-MT: "Stop 12345, Line 123: 11:34, 12:08, 12:41 - Information current as of 11:45	Stop number is confirmed along with the route. The next three times reflect the next three bus arrivals along with the time the information was generated.
Kommende afgange fra: Fyrrevej 14:45: 601 Låddenhøj 15:13: 855 Stændertorvet 15:15: 601 Låddenhøj 15:45: 601 Låddenhøj 16:15: 601 Låddenhøj	Coming departures from the stop Fyrrevej 14:45 departs line 601—destination Laadenhoej, etc. The customer cannot see if it's scheduled or real-time information. But if they know the scheduled timetable and the time differs, then they know it's real-time information.
5:07 p.m. 14624) Pulaski & Fullerton 53 to 31st DUE & 11 MIN Reply S)ervice Bulletings R)efresh	As of 5:07 p.m., at stop 14624 (at Pulaski & Fullerton), Bus Tracker estimates that a #53 bus to 31st is due to arrive, and then another one should arrive in about 11 min. You can reply to this message with "S" to get any service bulletins that may affect your trip (customer alerts), or "R" to get the latest, most updated result for the same stop.

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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Washington, D.C. 20001

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