

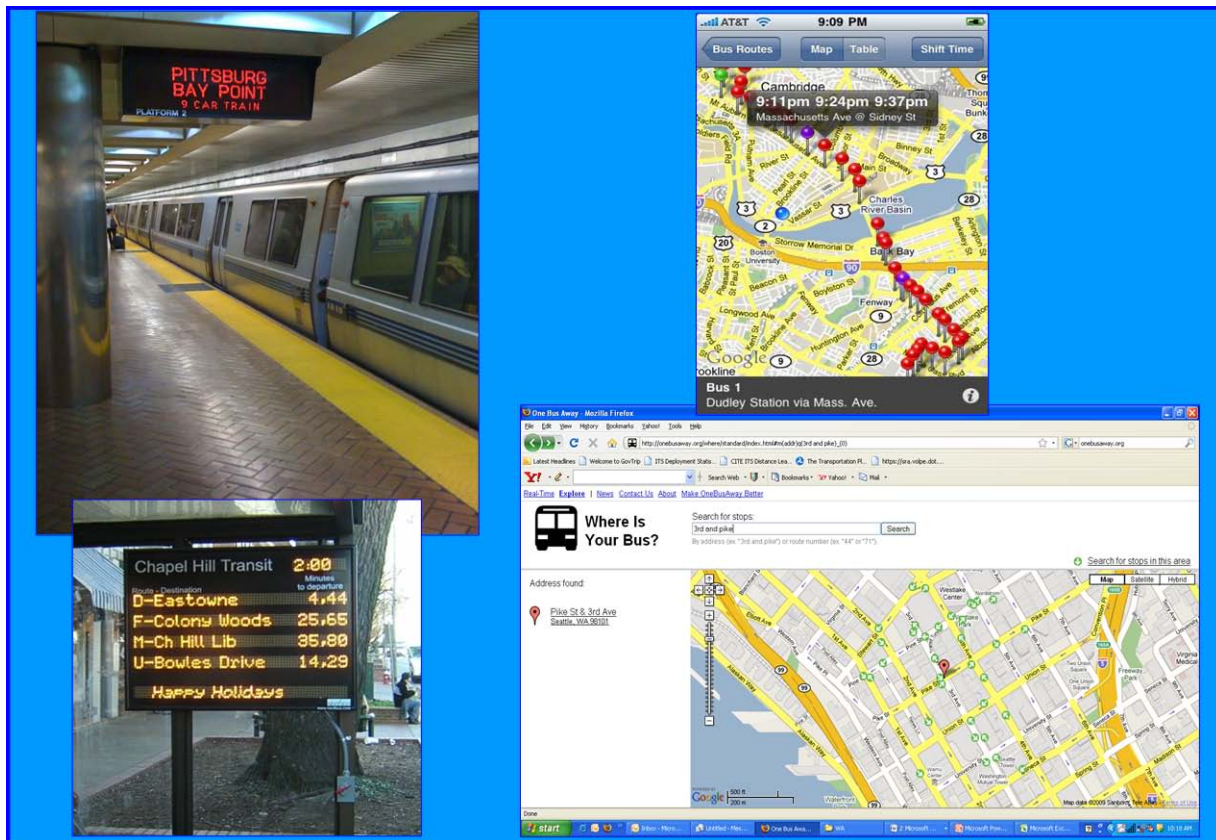


U.S. Department
of Transportation

**Federal Transit
Administration**

Traveler Information Systems and Wayfinding Technologies in Transit Systems

May 2011



Summary of State-of-the-Practice and State-of-the-Art Applications

FTA-MA-26-7998-2011.1

Cover images (clockwise from upper left): Bay Area Rapid Transit's Embarcadero Station vehicle arrival dynamic message sign (source: US DOT Volpe Center); Massachusetts Bay Transportation Authority's Google Transit application (source: US DOT Volpe Center); Seattle's One Bus Away Internet application (source: OneBusAway.org); Chapel Hill Transit Next Vehicle dynamic message sign (source: NextBus)

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TRAVELER INFORMATION SYSTEMS AND WAYFINDING TECHNOLOGIES IN TRANSIT SYSTEMS

Summary of State-of-the-Practice and State-of-the-Art Applications

May 2011

Prepared by: U.S. DOT's Research and Innovative Technology Administration
John A. Volpe National Transportation Systems Center

Report # FTA-MA-26-7998-2011.1



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Acronyms and Abbreviations

ADA	Americans with Disabilities Act
APC	Automatic Passenger Counter
API	Application Programming Interface
ATM	Automated Teller Machines
AVL	Automatic Vehicle Location
CAD	Computer-aided dispatch
DMS	Dynamic Message Sign
DOT	Department of Transportation
EFC	Electronic Fare Collection
EPD	Electronic Paper Display
GPS	Global Positioning System
GTFS	General Transit Feed Specification (formerly <i>Google Transit Feed Specification</i>)
ISP	Internet Service Provider
ITS	Intelligent Transportation System
IVR	Interactive Voice Response
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LORAN	Long Range Aid to Navigation
MPO	Metropolitan Planning Organization
NFC	Near Field Communication
NYS DOT	New York State Department of Transportation
OSS	Open Source Software
OTS	Off-the-Shelf
PDA	Personal Digital Assistants
QR	Quick Response [Code]
RIAS	Remote Infrared Audible Signage
RSS	Really Simple Syndication
SIM	Subscriber Identity Module
SDP	Schedule Data Profile
SOA	Service Oriented Architecture
SMS	Short Message Service, commonly known as Text Messaging
TTS	Text-To-Speech
WAP	Wireless Access Point

Acronyms/Abbreviations for Transit Agencies Referenced

AC Transit	Alameda-Contra Costa Transit District (Oakland, CA)
AT	Arlington Transit (Arlington, VA)
BART	Bay Area Rapid Transit District (Oakland, CA)
CalTrain	Peninsula Corridor Joint Powers Board (San Carlos, CA)
CapMetro	Capital Metropolitan Transportation Authority (Austin, TX)
CARTA	Charleston Area Transportation Authority (Charleston, SC)
CATA	Capital Area Transit Authority (Lansing, MI)
CATA	Centre Area Transportation Authority (State College, PA)
CT	Community Transit/Snohomish County Public Transportation Benefit Area Corporation (Everett, WA)
CTA	Chicago Transit Authority – RTA Service Board (Chicago, IL)
CUE	Fairfax CUE Bus System – City University Energy-Saver (Fairfax, VA)
C-UMTD	Champaign-Urbana Mass Transit District (Urbana, IL)
DART	Dallas Area Rapid Transit (Dallas, TX)
DASH	Alexandria Transit Company (Alexandria, VA)
DTA	Duluth Transit Authority (Duluth, MN)
GoTriangle	GoTriangle is a partnership of seven public transportation agencies in the Raleigh-Durham-Chapel Hill, NC Region
HHA	Hamburger Hochbahn AG/Hochbahn Rail Company (Hamburg, Germany)
Houston Metro	Metropolitan Transit Authority of Harris County (Houston, TX)
KC Metro	King County Metro/King County Department of Transportation (Seattle, WA)
LACMTA	Los Angeles County Metropolitan Transportation Authority (Los Angeles, CA)
LTD	Lane Transit District (Eugene, OR)
MARTA	Metropolitan Atlanta Rapid Transit Authority (Atlanta, GA)
MBTA	Massachusetts Bay Transportation Authority (Boston, MA)
MCTS	Milwaukee County Transit System (Milwaukee, WI)
MDT	Miami-Dade Transit (Miami, FL)
Metra	Northeast Illinois Regional Commuter Railroad Corporation – RTA Service Board (Chicago, IL)
Metro	Metro Transit (Madison, WI)
MT	Metro Transit/Twin Cities Metropolitan Council (Minneapolis, MN)
Metro	Oregon Metro – Metropolitan Planning Organization (Portland, OR)

MTA	New York Metropolitan Transportation Authority (New York, NY)
MTR	Mass Transit Railway of Hong Kong (China)
MTTA	Metropolitan Tulsa Transit Authority/Tulsa Transit (Tulsa, OK)
Muni	San Francisco Municipal Railway (San Francisco, CA)
NJ Transit	New Jersey Transit Corporation (Newark, NJ)
NS	Dutch Railways/Nederlandse Spoorwegen (The Netherlands)
NTD	Norwalk Transit District (Norwalk, CT)
NYC Transit	MTA New York City Transit (New York, NY)
Pace	Pace Suburban Bus Service – RTA Service Board (Arlington Heights, IL)
PAAC	Port Authority of Allegheny County (Pittsburgh, PA)
PATH	Port Authority Trans-Hudson Corporation (Jersey City, NJ)
Pierce Transit	Pierce County Transit/Pierce County Public Transportation Benefit Area Corporation (Tacoma, WA)
PS	Portland Streetcar (Portland, OR)
RTA	Greater Cleveland Regional Transit Authority (Cleveland, OH)
RTA	Regional Transportation Authority (Chicago, IL)
RMV	Rhein-Main-Verkehrsverbund (Frankfurt, Germany)
SamTrans	San Mateo County Transit District (San Carlos, CA)
SCTS	Sioux City Transit System (Sioux City, IA)
SEPTA	Southeastern Pennsylvania Transportation Authority (Philadelphia, PA)
Sound Transit	Central Puget Sound Regional Transportation Authority (Seattle, WA)
STM	La Societe de Transport de Montreal (Montreal, Canada)
Tokyo Metro	Tokyo Metro/ <i>formerly</i> Eidan - Teito Rapid Transit Authority (Tokyo, Japan)
The T	Fort Worth Transportation Authority (Fort Worth, TX)
TriMet	Tri-County Metropolitan Transportation District of Oregon (Portland, OR)
UTA	Utah Transit Authority (Salt Lake City, UT)
VRE	Virginia Railway Express (Alexandria, VA)
VTa	Santa Clara Valley Transportation Authority (San Jose, CA)
WMATA	Washington Metropolitan Area Transit Authority (Washington, D.C.)
WSF	Washington State Ferries - Washington State Department of Transportation (Seattle, WA)

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Executive Summary

PROJECT SUMMARY:

The Federal Transit Administration (FTA), Office of Mobility Innovation (TRI-10), has asked the USDOT's Research and Innovative Technology Administration's (RITA) John A. Volpe National Transportation Systems Center (Volpe Center) to study and evaluate the industry and traveler benefits associated with transit wayfinding (the process of reaching a destination in a familiar or unfamiliar environment) and route information technologies.

***Wayfinding** describes the process of reaching a destination, whether in a familiar or unfamiliar environment (KRW, 1996).*

***Wayfinding technologies** require the use of a wide range of existing and state-of-the-art technological advances to provide travelers with information at three key stages of travel: pre-trip, en route, and at the station.*

The primary goal of this FTA study is to expand the use and application of wayfinding technologies by the transit industry, which can in turn, help transit agencies increase their ridership. This study contains:

- **A Wayfinding Primer (Chapter 1)** that reviews various wayfinding elements, identified as basic technology, state-of-the-practice, state-of-the-art, or future technology. The primer was compiled from recent literature, web reviews, and transit agency phone and on-site interviews regarding wayfinding or route information technologies that were conducted in 2009.
- **Summary of Wayfinding Deployments (Chapter 2)** which includes opportunities, challenges, lessons, and recommendations to expand the use of these technologies in nine metropolitan areas. Areas reviewed are (1) San Francisco, California, (2) Portland, Oregon, (3) Seattle, Washington, (4) Chicago, Illinois, (5) Houston, Dallas, and Austin, Texas (6) Washington, D.C., (7) New York City (New York – New Jersey). This chapter compiles information gathered during phone and on-site interviews with representatives of 63 public and private organizations across the nation.
- **Conclusions and Opportunities (Chapter 3)** for deploying and utilizing an assortment of wayfinding technologies for transit services.

SUMMARY OF KEY FINDINGS:**(1) Technology Opportunities:**

- **Real-time, quality data leads to better information at lower costs:** With the availability and low cost of new wayfinding technologies, transit agencies are increasingly moving toward information delivery at all stages of travel. With the proliferation of systems that provide real-time vehicle arrival data or vehicle load capacities, the type of information available for display is expanding beyond the traditional information, i.e., schedules, fare, destinations, and service alerts. The design and delivery are also rapidly changing. Thus, transit agencies are actively seeking to incorporate a wider breadth of newer and less expensive traveler information technologies.
- **New technologies allow for collaborative partnerships and dynamic markets:** Transit agencies are becoming savvier and thinking ahead with regard to advanced wayfinding technologies. For example, a wide variety of agencies are working with and making their real-time data available to third party application developers, bringing new applications to transit customers on a variety of platforms. The proliferation of real-time transit information has the potential to significantly strengthen transit's position to capture new riders by removing uncertainty in transit use.
- **New technologies allow for personalization:** Third party applications are allowing transit data to be used in a more personalized method and to reach a wider audience. A number of new efforts, such as mash-ups are also developing nicely, but their full impact is still under review. (Mash-ups are web applications that integrate data or functionality from one or more sources into a single application.)

(2) Challenges in Implementation:

- **Legal:** Transit agencies vary widely in their data sharing policies. Ownership of real-time data, creation of user agreements, intellectual property rights, and copyright or licensing restrictions have arisen as the greatest legal challenges to developing and gaining full value from wayfinding technologies.
- **Institutional:** Many transit agencies see traveler information as a trade-off between funding operations and maintenance activities or developing advanced real-time traveler information systems. In addition, a number of transit agencies lack resources or internal staff knowledge to develop and maintain advanced wayfinding solutions. Even today, there is an internal resistance to utilizing advanced technologies, especially those that accurately track real-time performance.
- **Technical:** Common technical challenges facing transit agencies in implementing state-of-the-art wayfinding solutions fall into several categories: data and systems integration, global positioning systems (accuracy and multiple antennae), data (standards, real-time, static), and obsolescence (piecemeal approach, proprietary systems, changing technology). The next major advancements are likely to occur in the development of

real-time data availability and data sharing, in particular for emerging cooperative systems.

(3) Lessons Learned:

- Roll out real-time information systems slowly.
- Use an interdisciplinary team to design and develop wayfinding systems.
- Include an evaluation component into the implementation of wayfinding technologies to understand how customers use them and assess effectiveness.

(4) User Needs:

In the interviews, agencies identified needs for technical and policy guidance and best practices. Two of the most common needs are below.

- **Real-time data:** Agencies expressed several needs, including guidance on sharing real-time transit data and the development of real-time data standards.
- **Legal issues:** Needs included assistance in overcoming legal issues involved in contracting for customer information providers and guidance in open data issues.

Preliminary findings from this 2009-2010 transit wayfinding and traveler information technology assessment were provided to FTA staff and proved instrumental in guiding a number of the activities included in the FTA's *ITS Research Plan – 2010-2014*. Fifteen relevant transit wayfinding and traveler information projects were proposed and their eight topics are listed below. A full description of these proposed projects as they appear in the FTA's *ITS Research Plan – 2010-2014* are located in Appendix D.

Epilogue

In the time since the site visits, there have been advances in both the technology and its adoption and use for providing the riding public with information. Because of rapid evolution, agencies are taking even newer approaches to the institutional, legal, and technical challenges in sharing data and information with the public. One of the more significant advances is the inclusion of Global Positioning Systems (GPS) into smart phones that has triggered a proliferation of applications that combine maps, schedules, and locational services. Hundreds of these applications are now available to provide transit information using a variety of user interfaces. Examples include:

- The Chicago Transit Authority's website provides status updates for its train lines and bus routes; it also lists 13 privately developed applications that provide transit system information. The applications include web, desktop, and mobile applications for smart phones and Blackberries. The website also includes information on how to install a *do-it-yourself bus tracker display* to display bus arrival times in a lobby or store.
- The Metropolitan Transportation Authority-New York City Transit (MTA NYC Transit), the Massachusetts Bay Transportation Authority (MBTA), and the Washington Metropolitan Area Transit Authority (WMATA) have shifted away from their previous restrictive policies concerning sharing of data and schedule information. As noted in the case study, it was formerly MTA policy to challenge the legality of the sale of a software application that used MTA Metro North data. The agency required a freedom of information request before providing quarterly schedule updates. With a change in leadership, the MTA now actively promotes the distribution of service information to the public. In January 2010, the MTA announced a new website that included real time service status, as well as a new developers' resource center where data is available to software developers to create applications.
- In Massachusetts, both the State Department of Transportation and the MBTA now host a developers' website. The MBTA now provides real time travel information for all of its 190 bus routes.
- In 2010, WMATA initiated its *Transparent Metro Data Sets for Developers*, a program to provide the general public and regional partners with access to data. It includes information on bus schedules, routes and stops, as well as metro rail arrival information and system incidents. The program also includes feedback with external stakeholders. The stated vision of the program is to *"make Metro transit data publicly available for the purpose of general transparency and of easily developing...other third party applications."* (WMATA Board Information Item IV-D, Customer Services, Operations, and Safety Committee 6.10.2010)

"We need to get out of our own way and instead get out in front of the data sharing revolution. By making access to our data directly from our website, we are encouraging the developer community to do the work we can't to create applications for transit riders, at no additional cost to the agency."

Jay Walder

MTA General Manager
MTA Press Release, 1.13.2010

Regarding previous reticence to share information with the public, Jeffrey Mullan, Secretary of MassDOT, was quoted saying, "Those days are over. What the open-data initiative has done is permitted people who are 'outside of transportation' to help us perform our core mission. Even just letting people have access to our data proves to people that we're willing to trust others."

Boston Globe, 4.7. 2010 "T taps tech-savvy to keep riders in loop"

It is expected that this field will continue to evolve rapidly, creating benefits for both transit agencies and their customers. The speed of change, however, requires that agencies continue to grapple with legal, institutional, and technical challenges to technology adoption and use.

Introduction

Transportation-related information technologies—including those installed in vehicles, on personal mobile devices, or as part of the infrastructure—have grown significantly in the past several years, leading to increased consumer expectations for easily accessible and instantaneous traveler information. Many transit agencies have lagged in disseminating transit information in a manner compatible with the needs and expectations of the public. For example, many transit agencies track vehicles with Automatic Vehicle Location (AVL) systems, but do not process the information to provide next bus arrival predictions, which could be transmitted via websites, smart phones, or text message to customers en route, or waiting at transit stations. Or an agency may track vehicles and make the information available on a website, but not make the information accessible in a format that can be read on a smart phone. Where transit agencies have not kept pace with advances in technology, this delay represents missed opportunities to leverage the benefits these technologies provide both for meeting the information needs of current transit customers, and for potentially attracting new customers.

In support of the Federal Transit Administration's (FTA) Office of Mobility and Innovation, a team from the U.S. Department of Transportation's (USDOT) John A. Volpe National Transportation Systems Center (Volpe Center) was charged with studying and evaluating transit wayfinding and route information technologies and strategies. The purpose of the study is to provide an assessment of current and future trends in the application of traveler information technologies as a means to expand transit agencies' deployments of these tools, which may result in an increase in transit ridership.

The main product of this study is a technology evaluation that:

- Offers an understanding of wayfinding/route information products and services.
- Provides an overview of the benefits of these technologies and services for transit agencies and users.
- Identifies challenges experienced by transit agencies regarding the use and implementation of wayfinding technologies, and gaps that exist in current technologies.
- Identifies user needs to achieve broader deployment of wayfinding technologies by transit agencies.

This report is organized into three main sections:

- **Chapter 1: Wayfinding Primer** reviews the current state of the practice, the state of the art, and the potential for the future use of wayfinding technologies at national and international transit agencies.
- **Chapter 2: Wayfinding Deployment** summarizes experiences with wayfinding technology deployments in select metropolitan areas and by leading transit agencies.

- **Chapter 3: Conclusions and Opportunities** identifies challenges to overcome and offers suggestions for both federal and local agencies to expand wayfinding applications and deployments.

The research findings and conclusions presented in this report were informed by the following sources:

- **Literature reviews and Internet searches:** The team investigated existing wayfinding research, deployments, and identified leading transit agencies in the field. Information from this review informed the development of Chapter 1, Wayfinding Primer. See Appendix A for a bibliography and summary of sources.
- **Telephone interviews:** The team interviewed public and private transportation agencies identified as being leaders in the innovative use of transit wayfinding technologies. The purpose was to collect information on the use and application of wayfinding technologies, understand the associated challenges of wayfinding technologies, assess agency needs, and determine the most appropriate field locations for on-site interviews.
- **On-site interviews:** The team built upon the information collected from initial telephone interviews to provide a greater depth of analysis regarding the successful deployment of transit wayfinding technologies. In many cases, Volpe Center staff were able to meet individually with employees from different disciplines within the same organization. For example, when meeting with transit agencies, staff from operations and maintenance, information technology, or marketing were asked about their respective views and understanding of transit wayfinding technologies and related issues. These face-to-face meetings, coupled with hands-on use of, or demonstration of specific technologies by agencies, provided perspectives and insights not available by telephone.

A total of 63 public and private organizations from across the nation, including transit agencies, state departments of transportation, university research centers, software developers, metropolitan planning organizations, and others were interviewed as part of this study. Two interview guides, one for transit agencies and one for wayfinding technology application developers and service providers, were employed. The former includes questions related to wayfinding markets, current products and services used for wayfinding/route information, product development, data sharing, the value and benefits of wayfinding products and services, costs, challenges and needs, future direction, and other topics. The latter includes questions related to business arrangements, the future direction of wayfinding technologies, and other topics. Additionally, Volpe Center staff visited seven major metropolitan areas where transit agencies were identified as leaders in the innovative use of transit wayfinding technologies. The full list of interviewees can be found in Appendix C.

Chapter 1. Wayfinding Primer

This chapter describes various wayfinding elements, categorized as basic technology, state-of-the-practice, state-of-the-art, or future technology. It was compiled from recent literature, web reviews, and transit agency phone interviews conducted in the first half of 2009 regarding wayfinding/route information technologies.

Wayfinding describes the process of reaching a destination, whether in a familiar or unfamiliar environment (KRW, 1996). Wayfinding consists of three stages (TTI and NuStats, 1999):

- Stage 1: A person identifies landmarks and begins to orient him or herself using the landmarks as references.
- Stage 2: Landmark knowledge develops into route knowledge. The person builds travel directions within the framework of familiar landmarks and visualizes travel plans as a series of actions that take him or her from an origin to a destination.
- Stage 3: After gaining navigational experience in a particular environment, a person develops survey knowledge of the environment including landmarks, routes, and approximate travel costs between origins and destinations.

Traveler information systems provide transit customers with the knowledge needed to facilitate and accelerate the wayfinding process. Traveler information systems and accompanying technologies that deliver information may help individuals to better plan transit trips and decrease frustrations or barriers associated with transit use, especially for new or unfamiliar transit riders (Multisystems, Inc., 2003).

Three key elements of wayfinding technology and applications are:

- 1) **Information Content:** Travelers require transit information to understand and navigate a transit system. Additional information can improve customer experience. For example, location of transit stops is vital information for a transit user. Accurate location of transit vehicles themselves further improves customer experience.
- 2) **Information Format:** Transit information can be organized in several formats to facilitate communication with transit users. For example, information about stops and vehicles can be presented as a table, map, or text.
- 3) **Information Delivery Media:** Providers can convey transit information to customers through a variety of media, including print, online, displayed on dynamic message signs, or accessed via mobile devices.

Recent technological advances in these three components are changing the nature of wayfinding for transit travelers and transit managers. New mobile technologies allow for en route decision making and, thus, changing the nature of the transit experience. Further advances in interoperability are supporting advances in content, format, and delivery—making it easier to access and use multi-source data, facilitating multi-modal connections.

The remainder of this chapter defines how the wayfinding elements are employed and used in different contexts depending on their level of technology or the particular desired use and strategy. Examples of technologies are provided, along with examples of how agencies or companies are promoting their usage,¹ and any foreseeable challenges, if they exist, to the widespread development and deployment of the technology, are noted.

Tables 1, 2, and 3 on the following two pages provide a summary of the wayfinding elements, uses, strategies, and levels of technology. The levels of technology include a progression from basic technology to state-of-the-practice, state-of-the-art, and future technology. The tables also identify the trip stages for which each element is feasible or useful. Trip stages are defined as: pre-trip (PT), at-station (AS), en route (ER), and all stages (ALL). The tables also show that despite advancements in technologies, some basic technologies remain important (and cost-effective) at each successive stage. For example, static signage as a basic element of transit wayfinding strategies will likely remain an important feature in future transit systems.

Standards

Standards increase interoperability between devices and between transit providers and their customers. Standards are a key component of interoperability. FTA, with the American Public Transportation Association (APTA), has worked to develop and promote Transit Communications Interface Profiles (TCIP), through the USDOT ITS standards development program. TCIP provides a standard approach to exchanging key information needed by information technology systems deployed by public transport agencies. Other non-standard formats are also in use by transit agencies.

¹ Citation of any specific product or private entity does not imply endorsement by the federal government, U.S. DOT, FTA or the authors. Likewise, any omission of a product or private entity should not be assumed as a negative connotation on that product or private entity by the federal government. Agencies, products and private entities have been included as a result of interviews and document reviews, which was a thorough, but not all-encompassing research endeavor.

Table 1: Wayfinding strategies by level of technology (information delivery media)

Uses	BASIC	STATE-OF-THE-PRACTICE	STATE-OF-THE-ART	FUTURE
Natural & Built Landmarks	Built environment (architectural design) (ER, AS)			Standardized architectural design elements of new or remodeled transit stations (ER, AS)
Signage	Signage – static fixed signage (ER, AS)	Signage – dynamic and mobile signage (ER, AS)	Remote Infrared Audible Signage (RIAS) (AS)	
Public Announcement	Live voice (ER, AS)	Recorded voice (ER, AS)	Automated – text-to-speech (ER, AS)	
Telephone	Landline to Customer Service Center (PT)	Cellular access to live and automated Customer Service Center (ALL)	Interactive Voice Response (IVR) (ALL)	
Human Assistance	Human assistance (ER, AS)			
Printed Materials	Printed materials (ALL)			
Personal Computer	Networked – stationary (PT)		Networked – mobile (ALL)	
Mobile Device		Non-networked (ALL)	Networked – centralized (ALL) Quick Response (QR) codes (ER, AS) Global Positioning Systems (GPS) (ER, AS)	Networked – decentralized (ALL)
Transit Television		Transit TV (ER, AS)		Personalized TV (ER)
Kiosk		Non-networked (AS)	Networked – interactive (AS)	
Trip Stages: Pre-Trip (PT), En Route (ER), At-station/Stop (AS), All Trip Stages (ALL)				

Table 2: Wayfinding strategies by level of technology (information content)

Uses	Basic	State-Of-The-Practice	State-Of-The-Art	Future
Routes	Routes (ALL)	Route choices/Best route (PT)	Real-time route info (ALL)	
Stations/Stops	Stations/stops (ALL)	Station access (ALL)		
Fare	Schedules (ALL)	Travel mode & route fare/cost options – Financial Comparisons (PT)	Financial Comparisons (PT)	
Service Alerts	Elevator/escalator station access (ALL) Signage/oral instructions (AS)	Service alerts (ALL)	Customized service alerts (ALL)	
Real-Time Location		Self (ER, AS)	Transit vehicles (ER, AS)	All vehicles (ALL)
Destinations	Station/stop names (ALL)	Non-integrated (PT) Landmarks/Points of Interests (PT)	Integrated (ALL)	
Vehicle Passenger Load	Seasonal surveys (PT)	Using APC for planning (PT)		Vehicle passenger load available to passenger (ALL)
Trip Stages: Pre-Trip (PT), En Route (ER), At-station/Stop (AS), All Trip Stages (ALL)				

Table 3: Wayfinding strategies by level of technology (information format)

Uses	Basic	State-Of-The-Practice	State-Of-The-Art	Future
Map	Hardcopy map (ALL)	Personalized: Web-based (PT)	Personalized: Mobile Device (ALL)	Personalized: PDA/Mobile Device with GPS – “You are here” message (ALL)
Table	Table (ALL)		Dynamic Table (ALL)	
Text	Text (ALL)		Dynamic Text (ALL)	
Audio	Customer Service Center (PT) Operator/Station public address (ER, AS)	508 Compliant website & reading software (PT) ADA-Required In-Vehicle/Station stop announcements (ER, AS)	Station direction from Remote Infrared Audible Signage (RIAS) (AS)	Personalized: PDA/Mobile Device with GPS – “You are here” message (ALL)
Website	Website – static information (PT)	Website – dynamic information (PT)	Website – frequent updates (ALL)	Website - RSS feeds (ALL)
Trip Planner		Single mode – static and non real-time (PT)	Multimodal and/or real-time (ALL)	Multimodal and real-time (ALL)
Electronic Message		E-mail (PT) Really Simple Syndication (RSS) (PT) Short Message Service (SMS) (ALL)	E-mail (ALL) Really Simple Syndication (RSS) (ALL)	Real-time Blast regarding directions and environs (private sector link) (ER, AS)
Trip Stages: Pre-Trip (PT), En Route (ER), At-station/Stop (AS), All Trip Stages (ALL)				

1.1 Transit Information Content

Travelers require specific information to determine whether transit is the best mode of travel for a given trip and to find their way within a transit system. This section describes these required and available information elements.

1.1.1 Station/Stop, Route, Schedule, and Fare Content

Basic/State-of-the-Practice

Station/stop, route, schedule, and fare information are basic elements of wayfinding (TTI and NuStats, 1999). Location of station/stop tells travelers where they can enter and exit a transit system. Route information describes connections among stations/stops. Schedule information—departure, arrival, and trip duration—allows travelers to predict their timing. Fare information, while not temporal or spatial in nature, provides a cost component with which travelers can use to compare trade-offs among trip choices. Travelers use this information both pre-trip and en route.

State-of-the-Art/Future

The nature of station/stop, route, and schedule and fare information is changing, as is the way this information is communicated. Schedule information, in particular, is advancing rapidly as automatic vehicle location (AVL) systems add real-time estimates of arrivals, departures and travel times to complement static service schedules.

- King County Metro Transit, Chicago Transit Authority, Washington Metropolitan Area Transit Authority and many others are already collecting this information, presenting it on maps, tables, and in text, and delivering it to users electronically via in-station and on-vehicle dynamic message signage, personal computers, and mobile devices.
- Tri-County Metropolitan Transportation District of Oregon, the Chicago Transit Authority, Bay Area Rapid Transit, and other agencies are not only displaying real-time arrival times, but also sharing the underlying data with software developers. By focusing on data accuracy and data sharing, these transit agencies are able to shift a portion of application development for web and mobile devices to third party individuals and companies. These external programmers use this data in ways agencies “may never have dreamt of, or had resources to provide” (Moore, 2009).
- Independent and third-party developers often ‘scrape,’ or automatically extract from the web, published schedule information from agencies that are otherwise reluctant to openly share their data. Developers in Philadelphia scraped the Southeastern Pennsylvania Transportation Authority’s commuter rail schedules to build *iSepta* and

septime—web applications aimed at commuters with mobile devices (Kirk, 2008; *septime*, 2009).

- The Chicago Transit Authority does not openly share real-time data; instead the agency prefers to distribute that information via its online tool '*Bus Tracker*.' Yet the Chicago Transit Authority has not discouraged an independent developer from reverse engineering *Bus Tracker's* application programming interfaces (APIs), the software tools used by developers to access application information. As a result, the developer has created a proxy web server that other developers may query to obtain near-real-time information about Chicago Transit Authority vehicle locations (Reed, 2008).

Related Elements

Information content: Service alert, real-time location, destination, and vehicle load factor.

Information format: Map, table, text, website, trip planner, and electronic message.

Information delivery media: Signage, public announcement, telephone, human assistance, printed materials, personal computer, mobile device, and kiosk.

1.1.2 Service Alerts

Basic/State-of-the-Practice

Service alerts notify travelers of planned and unplanned outages, detours, and other irregularities in the transit system. For example, transit operators provide service alerts when service is running behind schedule or when construction projects require travelers to detour. Bay Area Rapid Transit issues service advisories when multiple trains are off schedule by 10 minutes or more (BART, 2009a). Agencies may also use service alerts to improve traveler safety during catastrophic man-made or natural events (Sander, 2007).

At the basic level, transit agencies relay service alerts to users while en route and at stations via signs and oral instructions from operators and station attendants. Service alerts are increasingly made available to travelers pre-trip via the web, email, Really Simple Syndication (RSS) feeds, and Short Message Service (SMS) or mobile text messaging.

As a result of the 1990 Americans with Disabilities Act requirements, station access information, especially for persons with disabilities, is now provided by the majority of transit agencies. Most transit websites contain an elevator and escalator status web page.



Figure 1: MBTA schedule information provided on i-Phone

State-of-the-Art/Future

State-of-the-art service alert systems allow travelers to customize the alerts they receive personally to be specific to routes, stops, and times. Customizable service alerts are available from a growing number of transit agencies and currently include Washington Metropolitan Area Transit Authority, the Los Angeles County Metropolitan Transportation Authority, and the Massachusetts Bay Transportation Authority.

Related Elements

Information content: Station/stop, route, and schedule.

Information format: Map, table, website, trip planner, and electronic message.

Information delivery media: Signage, public announcement, telephone, human assistance, printed material (for planned service alert), personal computer, mobile device, and kiosk.

1.1.3 Real-Time Location

Basic/State-of-the-Practice

Although real-time location information has existed since World War II via Long Range Aid to Navigation (LORAN), it was not until the advent of global positioning systems (GPS) in the early 1990s that real-time location became widely available to consumers for navigational purposes (LORAN, 2009; Global Positioning System, 2009). Today many travelers carry

mobile and wireless devices with embedded low-cost GPS functionality that provides the traveler's absolute location and relative motion at any time. Automatic vehicle location systems commonly generate real-time location information for transit vehicles and enable operators to track vehicle position. By merging real-time location of transit vehicles with traffic and congestion data, vendors (such as *NextBus*, *Clever Devices*, and *TransLoc*) are providing transit agencies and travelers with up-to-the-minute arrival times.

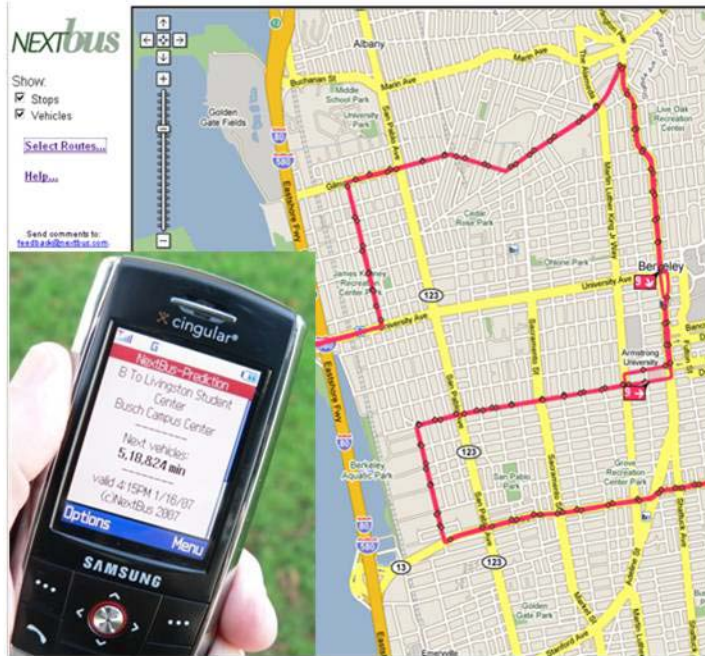


Figure 2: NextBus mapping and route information for San Francisco Bay Area

State-of-the-Art/Future

Merging real-time locations with other types of spatial information, and sharing these results with travelers, is driving advances in wayfinding (Schweiger, 2003). With these advances, travelers may fine-tune their travel plans pre-trip and make more informed decisions en route by acquiring real-time information via trip planners, electronic messages, and mobile devices (as noted in the San Francisco example in Figure 2). Sharing real-time information with travelers at all stages of their trips results in strong, positive net social benefits (Cham et al, 2003).

The collection and public dissemination of real-time location data faces several challenges. Maintaining data accuracy, ensuring the system is flexible enough to cater to a transit operating environment where changes can occur unexpectedly, maintaining timetable information, and automating detection of system failures are potential challenges (Schweiger, 2003). Factors having the most influence on the accuracy of bus arrival estimates are: route type, time of day, and the next arrival estimate; whereas, research has demonstrated that factors such as vehicle load factor, schedule deviation, and operator

characteristics appear to have little or no influence on vehicle arrival estimation accuracy (Crout, 2007).

Related Elements

Information content: Station/stop, route, schedule, destination/attraction, and vehicle load factor.

Information format: Map, table, website, trip planner, and electronic message.

Information delivery media: Signage, public announcement, telephone, personal computer, mobile device, and kiosk.

1.1.4 Destinations

Basic/State-of-the-Practice

Naming stations and stops after streets and well-known landmarks can facilitate system usage and orient travelers with their surroundings (TTI and NuStats, 1999). The Washington Metropolitan Area Transit Authority includes icons representing the U.S. Capitol, the White House, the Lincoln and Jefferson Memorials, and the Washington Monument on its system map. On its website the Massachusetts Bay Transportation Authority has a list of accessible subway stops nearest popular destinations including Harvard and MIT, Fenway Park, Boston Common, and Faneuil Hall Marketplace (MBTA, 2006). The Dallas Area Rapid Transit also lists weekly events accessible by the transit system on its website (DART, 2009).

State-of-the-Art/Future

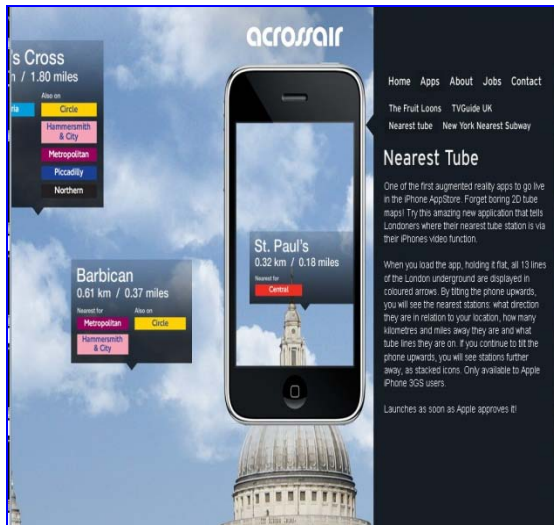


Figure 3: London's Nearest Tube—iPhone 3G Application

Third parties are leading the way in integrating transit information with a range of destination types, such as restaurants or specific businesses. For example, *Google Maps* integrates locations of local businesses with data provided by transit agencies, such as station locations, routing, and scheduling, as part of its *Google Transit* initiative.

A powerful development in layering transit and destination data has been “mashups” of maps and transit data with external data provided by third party and independent developers. Mashups are web applications that integrate data or functionality from one or more sources into a single application.

An example of a mashup is *One Bus Away*, a tool focusing on Seattle and surrounding King County. *One Bus Away* combines maps from *Google Maps* with stops, routes, and transit schedules, plus destination information from *Yelp.com* (Ferris and Watkins, 2009). By searching for ‘pizza’ near the start location ‘3rd and Pike’, the tool displays a color gradation map of all locations located within one bus ride of the start location. The tool displays a list of restaurants and associated ratings from *Yelp.com* and travel times to all the pizza restaurants. The pizza restaurants are also mapped. Clicking on a restaurant gives the user the option to visit the *Yelp.com* page for detailed reviews or get detailed transit travel instructions. *One Bus Away* is the product of two graduate students at the University of Washington.



It is reasonable to expect that future mashups of destinations and transit information will include service alerts and real-time vehicle location and schedule updates. In addition, GPS-enabled mobile devices may one day alert carriers of nearby services or amenities as the transit vehicles approach specific destinations.

Information content: Station/stop, route, schedule, service alert and real-time location.
Information format: Map, table, website, trip planner, and electronic message.
Information delivery media: Personal computer, mobile device, and kiosk.

Basic/State-of-the-Practice

Although it could be used to assist travelers in selecting less-crowded vehicles, load factor is neither collected nor shared with travelers as a standard practice. (Occasionally, past

vehicle passenger counts are made available in Annual Reports, planning documents, or project proposals.) This data is rarely systematically used, and most reporting of load factor is currently done by the vehicle operator to the dispatch office via radio. The Washington Metropolitan Area Transit Authority is unusual in providing its users with expected train capacity by broadcasting the number of cars in each train, using its next train arrival system (WMATA, 2009a).

State-of-the-Art/Future

Riders of the Bay Area Rapid Transit system have expressed a strong desire to receive real-time load factor data along with real-time location information, so they can choose to avoid full vehicles (BART Marketing and Research Department, 2009). Automatic passenger counters (APCs) and electronic fare collection systems (EFCs) are expected to enable collection and dissemination of this information to users in the future. Currently, a few transit agencies have integrated AVL, APC and EFC systems for utilizing this information to enhance and support real-time dispatching functions, if so desired.

Related Elements

Information content: Station/stop, route, schedule, and real-time location.

Information format: Map, table, website, trip planner, and electronic message.

Information delivery media: Signage, public announcement, telephone, personal computer, and mobile device.

1.2 Transit Information Format

Various information formats—the ways in which information is presented—can be used to facilitate communication with transit users. This section describes the range of available formats.

1.2.1 Maps

Basic/State-of-the-Practice

A map is a visual representation of an area. A transit map is a symbolic depiction highlighting relationships between stations/stops, routes, destinations, and attractions. Traditionally, maps are printed on paper and complemented or reinforced by stationary signs.

In recent years, the Internet has made interactive maps widely available. *MapQuest* and *Yahoo! Maps* popularized highway maps and interactive driving direction tools in the mid-

1990s, followed by *Google Maps* in 2005. Transit agencies have emulated these automobile trip planning services to create map-based trip planners for transit systems.

State-of-the-Art/Future



Figure 5: BART's system map on PDA display

A significant advance is the accessibility of interactive digital maps from personal computers and handheld mobile devices, including cell phones, personal digital assistants (PDAs), and GPS navigation units. Electronic maps displayed on networked mobile devices are increasingly able to display, not only routes and places, but real-time location of the device itself and the location of transit vehicles (King County, 2009; CTA, 2009). Examples include:

- As of May 2009, *Google Transit* displays station/stop, route, and schedule information for over 70 transit systems in 10 countries, using *Google Maps* technology (Google, 2009c). To participate, transit agencies must publish their transit information in the *General Transit Feed Specification* (GTFS) (Google, 2009b). The information is supplemented with *Google Maps*' local search, satellite, street, terrain, and buildings views, plus walking directions, and traffic.
- *OpenStreetMap* is an effort to provide free geographic data such as street maps to anyone who wants them. Contributors may geocode and upload landmarks, routes, and other features as desired. Developers are encouraged to use these maps in creative, productive, or unexpected ways (OpenStreetMap, 2009). Products of OpenStreetMap include a map of London's Underground and intercity buses in Western Europe.
- Houston Metro provides *iPod*-compatible bus route maps (METRO, 2008).



Figure 6: Houston MetroRail system map for iPod

Related Elements

Information content: Station/stop, route, service alert, real-time location, destination, and vehicle load factor.

Information format: Website and trip planner.

Information delivery media: Signage, printed material, personal computer, mobile device, and kiosk.

1.2.2 Tables

Basic/State-of-the-Practice

Non-interactive tables have traditionally been used to display static schedule and fare information on printed materials, signs, kiosks, and websites. Examples of static tables are found on brochures in transit stations and posted on signposts of most transit systems.

State-of-the-Art/Future

State-of-the-art tables are dynamic. Examples of dynamic tables include departure and arrival tables at airports and train stations and service alert information published on web pages, such as those provided by the Massachusetts Bay Transportation Authority's (MBTA, 2009). Other examples include:

- Washington Metropolitan Area Transit Authority has employed the use of dynamic train arrival tables at stations since 2000 (White, 2000).
- Due to the screen-size constraints of mobile devices, tables and lists have been convenient and popular ways to display multiple route and vehicle information on devices. Examples include the Chicago Transit Authority's *Bus Tracker* 'arrival' view (CTA, 2009), *TriMet Tracker* (TriMet Tracker, 2009), and *iBART* (iBART, 2009).

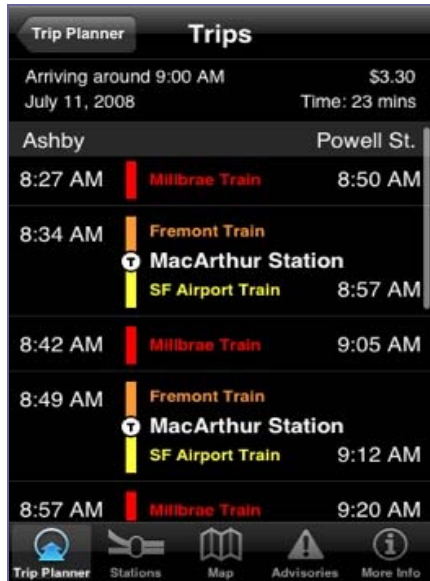


Figure 7: iBart display

Related Elements

Information content: Station/stop, route, schedule, fare, service alert, real-time location, destination, and vehicle load factor.

Information format: Text, website, trip planner, and electronic message.

Information delivery media: Signage, printed material, personal computer, mobile device, and kiosk.

1.2.3 Text

Basic/State-of-the-Practice

Written text is a basic form of communication and is used throughout transit systems to describe virtually all types of information including directions, routes, stops, times, and fares. Text may take the form of labels on a map, entries in a table, directions or notices on a sign, or descriptions of places, things, or policies. Text is also required under the 1990 Americans with Disabilities Act as an alternative message system to audio information.

The effectiveness of text can be enhanced in several ways (TTI and NuStats, 1999). Typefaces that are sans-serif, for example, are easier to read at a distance by people with visual impairments, children, and those with limited education. Examples of these fonts include Helvetica and Gothic. Stroke width, character and line spacing, and type size also affect readability, and appropriate guidelines should be considered with respect to use, visual angle, colors, and contrast (TTI and NuStats, 1999; KRW, 1996).

State-of-the-Art/Future

Delivery methods that convey text are advancing with the growth of dynamic message signs, text messages, email, and electronic maps available online or on mobile devices. These text delivery methods are covered throughout this section.

Related Elements

Information content: Station/stop, route, schedule, fare, service alert, real-time location, destination, and vehicle load factor.

Information format: Map, table, website, trip planner, and electronic message.

Information delivery media: Signage, printed material, personal computer, mobile device, transit television, and kiosk.

1.2.4 Audio

Basic/State-of-the-Practice

Enactment of the 1990 Americans with Disabilities Act has meant that audio information is a prominent alternative to visual information.² The regulation requires that any audio equipment provided by a transit agency be maintained in an operative condition (although the U.S. DOT's regulations on implementing the Act do not require the use of audio equipment). The requirement is that stop announcements be made in such a manner that they can be heard by every person riding the bus.

Audio communication has historically been the prime method for transmitting en-route traveler information, especially in-vehicle and at major transfer points. Today, audio systems, called annunciators, have taken on new forms, such as: electronic sign/audio annunciators at stops; information kiosks with audio capabilities at stops; or electronic sign/audio annunciators in vehicles. These systems provide both visual and audio

² The U.S. DOT ADA regulations at 49 CFR sections 37.167(b) and (c) require that stop announcements must be made on fixed route systems as follows:

(b) On fixed route systems, the entity shall announce stops as follows:

1. The entity shall announce at least at transfer points with other fixed routes, other major intersections and destination points, and intervals along a route sufficient to permit individuals with visual impairments or other disabilities to be oriented to their location.
2. The entity shall announce any stop on request of an individual with a disability.

(c) Where vehicles or other conveyances for more than one route serve the same stop, the entity shall provide a means by which an individual with a visual impairment or other disability can identify the proper vehicle to enter or be identified to the vehicle operator as a person seeking a ride on a particular route.

announcements on board transit vehicles automatically. Announcements typically include next stop, transfer location, and vehicle route and destination information.



Figure 8: WMATA Metrobus “Talking Sign”

Automatic annunciators relieve transit vehicle drivers of verbally making next stop and transfer location announcements for passengers. While the audible system ensures that persons with visual and hearing limitations obtain important stop and route-specific information, it also helps anyone unfamiliar with the transit system to identify the proper transit vehicle (route and direction) when boarding a vehicle, and the proper stop location when exiting the vehicle.

Pre-trip audio traveler information is also commonly provided via customer service centers. Specialized reading software enables transit agencies’ websites to be translated for individuals who are sight impaired. However, the software is primarily privately-used and the transit websites must be Section 508 compliant in most cases to obtain the greatest use of the reading software.

State-of-the-Art/Future

Transit environments are typically very noisy (cavernous stations, urban noise, internal and external vehicle noise, etc.) and not conducive to extensive reliance on audio information. In addition, the quality of the public address or intercom systems in any public location has largely been poor. With improved acoustical technologies, the quality of audio systems is improving over the historically muffled sound systems.

A test of *Remote Infrared Audible Signage* (RIAS) conducted in Seattle demonstrated that the system could eventually enable blind or visually impaired users to “hear” real-time and

static wayfinding transit information signage. Personal mobile devices are enabling travelers to obtain more real-time audio information on demand. In the future, personalized audible traveler directions utilizing mobile devices' GPS capabilities could be possible.



Figure 9: RAIS Personal Mobile Device being tested in Seattle

Related Elements

Information content: Station/stop, route, schedule, fare, service alert, real-time location, destination, and vehicle load factor.

Information format: Map, website, trip planner, and electronic message.

Information delivery media: Signage with annunciators, personal computer, mobile device, transit television, and kiosk.

1.2.5 Websites

Basic/State-of-the-Practice

Information available at transit websites ranges from basic service information on fares, schedules, and routes, to procurement notices, job postings, board minutes, and planning activities. As of 2009, an estimated 223 million Americans, or roughly 73 percent (73%) of the population, have access to the Internet (Wolfram Alpha, 2009a). The Internet presents transit information to existing and potential public transit users in a cost-effective way (Kenyon et al, 2001). Transit agency information technology staff report that Internet users are interested in basic customer information to help them plan trips and current information on construction diversions and unplanned incidents.

Transit website managers have used and continue to use a process of experimentation, customer feedback, and periodic redesign to develop their sites into tools for bus, rail, and paratransit customers to plan trips, and to access a variety of information (Schaller, 2002). The most important contributor to users' perceptions regarding online quality of service of transit websites is efficiency, defined as ease and speed of accessing desired information (Eriksson et al, 2007).

Importantly, web pages should be designed to provide information to all possible users. Section 508 of the Rehabilitation Act of 1973, (amended in 1998 and codified in 29 USC § 794d) requires electronic technology used by the federal government to be accessible to persons with disabilities. Five types of disabilities can affect Internet usage: visual, hearing, mobility, cognitive impairments, and seizure disorders. Examples of Section 508 standards that apply to websites and electronic documents include the following actions:

- Providing a text equivalent for every non-text element;
- Assuring all information conveyed with color is available without color;
- Providing row and column headers in all data tables; and
- Preventing the screen from flickering with a frequency greater than 2 Hz and lower than 55 Hz (Schaller, 2002).³

The standards apply to federal web sites but not to private sector websites (unless a site is provided under contract to a federal agency, in which case only that website or the portion covered by the contract would have to comply). Most transit agencies express a desire to provide accessibility of their website information to people with disabilities, although there has been some uncertainty as to whether transit agencies are required to under federal law (Schaller, 2002). A number of states do require all publicly-financed websites to comply with Section 508 or state-developed access standards.

In addition to agency-specific websites, many transit agencies have begun to use social networking sites as a means to quickly disseminate transit traveler information. Bay Area Rapid Transit, Washington Metropolitan Area Transit Authority, King County Metro and a growing number of other transit agencies are using third party website services like email or text message, social grouping, and video feeds to provide transit service alerts, special event information, or instruction on how to use the transit system. Social networking sites are often favored for the ability to make timely updates to data, and for the cost savings on marketing and website maintenance. These sites are recognized as important tools that transit agencies may use to increase customer communications, as opposed to replacements for traditional methods of communication (Metro Magazine, 2009).

State-of-the-Art/Future

State-of-the-art transit websites are common among medium and large agencies with large budgets and technical capability. Such websites are characterized by frequently updated news and service information, options to share service alerts via electronic messages and feeds, and online trip planners. Examples include:

³ See: www.section508.gov.

- Some agencies, including Utah Transit Authority, Metropolitan Tulsa Transit Authority, New Jersey Transit, and Bay Area Rapid Transit have mobile websites specifically designed to be viewed on mobile devices. These sites are designed to be simple so that they load quickly over cellular data networks.
- Washington Metropolitan Area Transit Authority, Tri-County Metropolitan Transportation District of Oregon, Bay Area Rapid Transit, and Miami-Dade Transit's Metrorail publish real-time vehicle arrivals on their websites.
- Chicago Transit Authority, King County Metro, and Sioux City Transit System display maps of real-time vehicle locations on their websites.
- Bay Area Rapid Transit also uses its website to advertise third party applications that utilize BART data to help riders make informed travel decisions (BART, 2009b).

Related Elements

Information content: Station/stop, route, schedule, service alert, real-time location, destination, and vehicle load factor.

Information format: Map, table, trip planner, and electronic message.

Information delivery media: Personal computer, mobile device, and kiosk.

1.2.6 Trip Planner

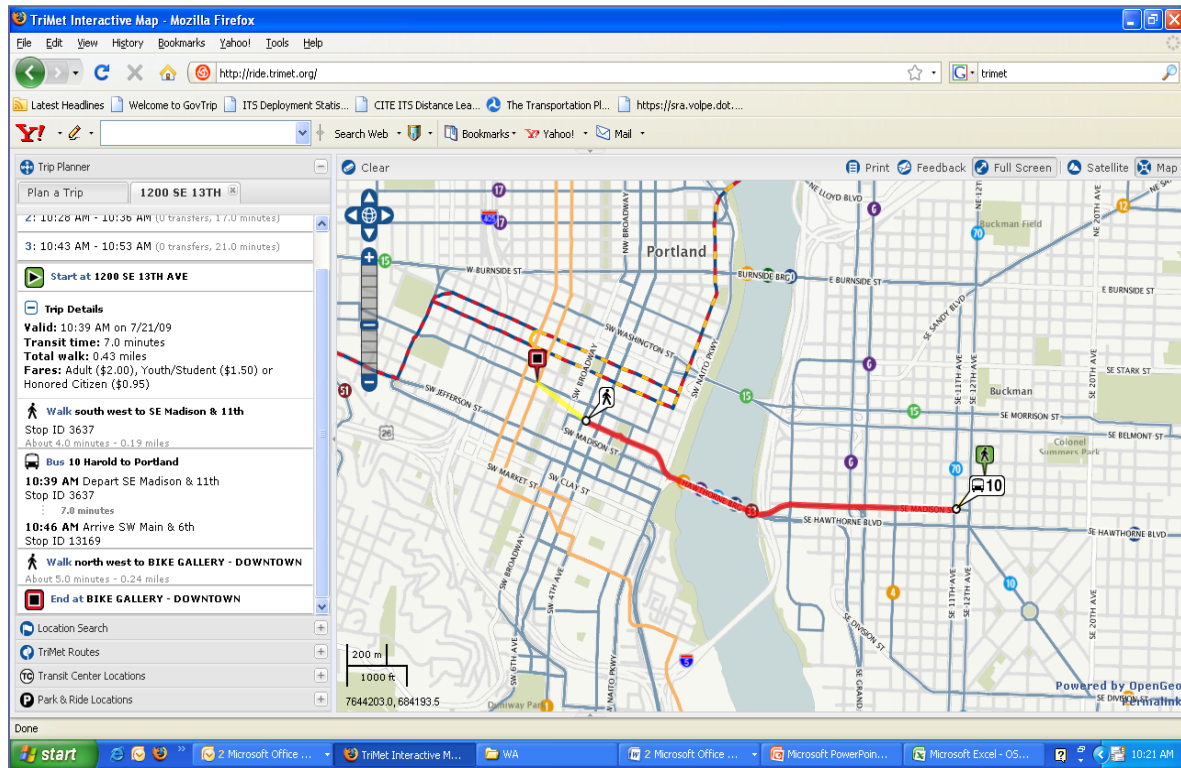
Basic/State-of-the-Practice

Trip planners, also known as journey planners, are specialized electronic search engines that find the best journey between two points by some means of transport (Journey planner, 2009). The first popular online trip planner, *Mapquest*, was released in 1996, and a popular trip planner from *Yahoo!* followed. These planners were focused on generating automobile driving directions and were closely integrated with maps. *Google Maps* began providing maps and trip planning functionality in 2005. Since then, *Google Maps* partnered with other firms to integrate directions and travel times for walking and public transit.

Many transit agencies now offer online trip planners for their systems (Radin et al, 2002). The transit trip planner applications prompt users to input origins and destinations to generate routes between points using available transit services. Transit planners for large agencies including the Washington Metropolitan Area Transit Authority, Bay Area Rapid Transit, Los Angeles County Metropolitan Transportation Authority, and the Massachusetts Bay Transportation Authority were introduced in the early to mid-2000s. These tools began largely as single-mode, single-agency applications and have grown to incorporate multiple modes for single trips. Over time, transit trip planners have been implemented in smaller markets. Austin's Capital Metro Transit, the Duluth Transit Authority, and the Greater

Cleveland Regional Transit Authority are examples of mid-sized agencies with online transit trip planners.

Figure 10: Tri-Met's Interactive System Map



Transit trip planners have also been developed for persons with physical and cognitive disabilities. A project at the University of South Florida's Center for Urban Transportation Research has developed a website to create and manage trip itineraries for persons with disabilities by their travel trainer and/or parent. The traveler carries a GPS-enabled mobile phone that signals when to get off the bus. The site allows the real-time tracking of the traveler and signals an alarm when the rider deviates from the planned route (Barbeau, 2009).

State-of-the-Art/Future

Advanced trip planners for public transit have incorporated planning for multiple modes and for service among multiple agencies.

- Western European countries lead development of countrywide, door-to-door, public transportation trip planners. Examples include *Transport For London* (United Kingdom), *Journey.fi* (Finland), OV9292 (The Netherlands), and *ResRobot* (Sweden). These trip planners generate trips for walking, biking, driving, and public transit.

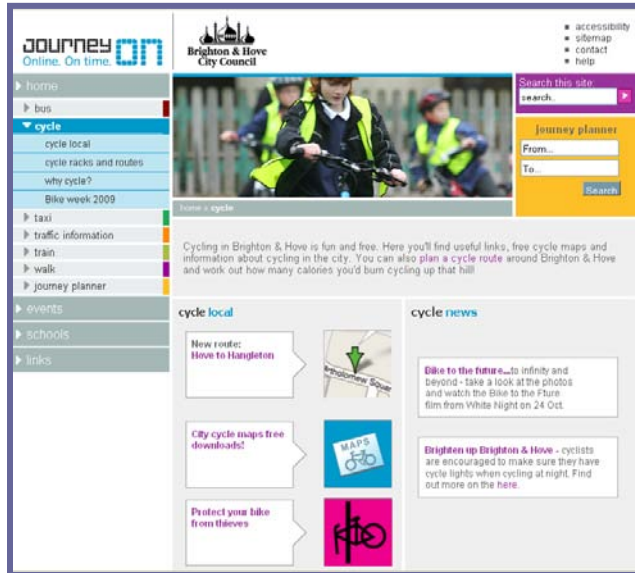


Figure 11: United Kingdom's *JourneyOn* travel itinerary website

- JourneyOn*, a transportation website provided by the Brighton and Hove City Council in the United Kingdom, generates travel itineraries of the modes mentioned above and provides distance, duration, calories expended, cost, and the carbon footprint for each. For walking and biking itineraries, it allows users to choose to generate either the flattest or shortest routes (JourneyOn, 2009).
- A-Train*, a trip planner for Atlanta, allows users to generate routes using different options: walk only, bike only, walk to transit, and bike to transit (A-Train, 2007).
- Fort Worth Transportation Authority has a web-based trip planner for its paratransit service.

Interfaces for transit trip planners are in development for use on mobile device websites. Bay Area Rapid Transit, Washington Metropolitan Area Transit Authority, and Chicago Transit Authority have mobile websites with simpler interfaces relative to their systems' respective transit trip planners available on their home website.

Advances in AVL systems and real-time location data collection analysis will improve trip planning applications in the future. Introduction of real-time location data from vehicles will improve accuracy of arrival, departure, and travel time estimates. And for users with GPS-enabled mobile devices, real-time data will improve estimated walking travel times.

Related Elements

Information content: Station/stop, route, schedules, service alert, real-time location, destination, and vehicle load factor.

Information format: Map, table, and website.

Information delivery media: Telephone, personal computer, mobile device, and kiosk.

1.2.7 Electronic Messages

Basic/State-of-the-Practice

Electronic messages are used by transit agencies to communicate delays, outages, detours, and other ad-hoc, event-based information. Dynamic message signage (DMS) is the oldest and most basic real-time electronic message format delivered to groups of travelers at fixed locations. Direct electronic messages can now be targeted to specific users over telecommunications networks. Direct electronic messages are 'opt-in' systems with which users must register and confirm they wish to receive. Electronic messages usually take the form of either email, SMS, or RSS.

Email has been a method of communicating electronically for the last 50 years, though it gained mainstream popularity in the 1990s along with the Internet. Modern email systems consist of computer server systems that accept, forward, or store messages on behalf of users, who only connect to the email infrastructure via personal computer or other network-enabled device for the duration of message transmission or retrieval. Transit agencies including New York City's Metropolitan Transportation Authority, Chicago Transit Authority, Washington Metropolitan Area Transit Authority, and Metro Transit in Madison, Wisconsin regularly use email to send alerts. The Washington Metropolitan Area Transit Authority provides email alerts customizable by time of day and route for Metrorail, as well as providing separate alerts for persons with disabilities related to access issues and elevator outages.

SMS is a communication service that allows interchange of short text messages between mobile telephone devices. SMS is used by transit agencies to communicate to travelers mobile devices via text messages. Bay Area Rapid Transit, Tri-County Metropolitan Transportation District of Oregon, and Massachusetts Bay Transportation Authority all use SMS systems.

An RSS feed is an Internet method for delivering information, such as news stories (or snippets of them). Travelers can take advantage of RSS feeds by subscribing to them using modern web browsers, email programs, RSS/news aggregators, and customizable start pages offered by major Internet services. Agencies that offer news and service alerts via

RSS feeds include Chicago Transit Authority, Duluth Transit Authority, Washington Metropolitan Area Transit Agency, New York City's Metropolitan Transit Agency, and New Jersey Transit.

State-of-the-Art/Future

Some transit agencies recognize the need to improve the technology used to deliver mass amounts of electronic messages in short periods of time. Examples include:

- In an assessment of New York City's Metropolitan Transit Agency's performance and vulnerability following severe regional flooding in August 2007, the agency recommended finding a communications provider capable of handling as many as 800,000 real-time email and text message alerts simultaneously (Sander, 2007).
- SMS communications are beginning to be used by travelers as an interactive wayfinding tool rather than a passive receiving tool. For several transit systems including Suffolk County, United Kingdom, King County Metro, and Port Authority of Allegheny County, travelers may text unique numeric codes that represent routes or bus stops and receive information regarding anticipated arrivals. Unique codes may be found on signs at bus stops. Vendors that provide this service include *RouteShout*, *Dadnab*, and *Nextbus*.



Figure 12: Dabnab offers one example of a transit stop text messaging service

Related Elements

Information content: Station/stop, route, schedule, service alert, real-time location, and vehicle load factor.

Information format: Text.

Information delivery media: Signage, personal computer, and mobile device.

1.3 Transit Information Delivery Media

Transit providers can convey information to customers through a variety of means. The following section describes the media or devices used to provide transit information.

1.3.1 Natural and Built Environment

Basic/State-of-the-Practice

In many ways, architectural design is used to deliver traveler information. Urban design traditionally focuses on the function of public space, the design of buildings and the arrangement of transportation systems, retail space, and other amenities. Urban planners and architects consider the use of spaces that are used commonly by the general public, including streets, plazas, parks and public infrastructure. Physical elements that orient people and aid in wayfinding include **paths, landmarks, nodes (entries and exits), edges (barriers), and districts** (Lynch, 1960; Passini, 1984). These elements enable the three-stage wayfinding process: identifying landmarks at origin and destination points, developing origin to destination route knowledge, and developing survey knowledge including landmarks, routes, and approximate travel costs between origins and destinations (TTI and NuStats, 1999).

Paths at the city-scale are perceived as horizontal channels of movement such as streets and transit fixed routes. Inside buildings, paths include hallways, stairs, escalators and elevators, and elements of horizontal and vertical circulation systems.

Landmarks are distinct points of reference including, at the city scale, parks, mountains, buildings, or bridges. In an indoor setting, a landmark is recognized as a clearly prominent element that is localized in space. Sculptures and landscaping elements are examples of landmarks in built environments. Spaces that are distinct in character compared to other spaces may be perceived as landmarks and used by travelers to orient themselves. Arts in Transit programs provide additional visual landmarks to help travelers identify stops, stations, or locations within large stations.

Nodes are the strategic spots of entry into a city or focal points of alignment during travel. The equivalent points in buildings include lobbies, other large open spaces, such as a transit terminal interior, and hallway intersections.

Edges are formed by boundaries or barriers that usually comprise linear elements, which cannot be used as paths. Rivers in cities and walls of buildings, particularly the exterior walls, are examples of edges. In transit, the terminus point of each route can be seen as one of the transit system's edges.

Districts are described as medium to large sections of space having some common identifying character, especially in terms of function. In cities, residential or commercial spaces can be called districts. In buildings, floors and wings usually have a common functional character and can thus be deemed as districts. Transit systems can have distinct fare districts or transfer points that segregate service into *de facto* districts.

State-of-the-Art/Future

New methods of spatial analysis and cognitive mapping may provide opportunities to design improved public spaces by measuring the properties of spatial layouts that users perceive: lines of sight along streets and corridors, visual fields from public spaces, and degrees of privacy and openness (Space Syntax, 2009).

- *Space Syntax* methods have been used by City of Oakland and Southern California Association of Governments (SCAG), the MPO in the Los Angeles Metropolitan Area, to analyze the locations of pedestrian-oriented land uses, bicycle and multi-modal transportation nodes, and bicycle and pedestrian routes. These agencies have used this information to determine where to allocate funds for improvements of visual identification of area, its use and modal linkages within an area (FHWA, 2009).
- *Space Syntax* methods have also been used in quantitative studies of movement and ingress/egress from London Underground stations (Chiaradai et al, 2005).

Related Elements

Information content: Station/ stop, route, and destination.

Information format: Physical design.

Information delivery media: Physical design.

1.3.2 Human Assistance

Basic/State-of-the-Practice

Transit operators, station agents, and customer service representatives play an important role in providing transit information to customers. Travel training programs are one area where human assistance is paramount. Travel training programs provide instruction to individuals who want to learn to travel independently using a fixed route transit system. Travel training participants, including those with disabilities or seniors, learn the skills necessary for independent transit riding, such as how to plan a trip, navigate to the correct transit stop/station, and how to board and disembark the vehicle.

Vehicle operators are another important conduit for communicating en-route wayfinding information. The 1990 Americans with Disabilities Act requires announcement of stops at

major intersections, transfer points and specific destination points. For systems that do not have automatic stop announcements, vehicle operators provide this service.

State-of-the-Art/Future

Partnering transit travel instruction with other technological advances that simplify the use of public transit will facilitate the increased integration and inclusion of persons with mobility difficulties into mainstream transit (Dorey, 2007).

- Researchers at the Center for Urban Transportation Research have developed a prototype software system that can be installed in off-the-shelf GPS-enabled cell phones. The software delivers prompts, such as “get ready” and “pull the cord now.” Use of the tool as part of the travel training curriculum further enhances transit rider independence and safety (NCTR, 2008).

Related Elements

Information content: Station/stop, route, schedule, fare, service alert, and destination.

Information format: Live or recorded voice.

Information delivery media: Call center, and live or recorded voice message.

1.3.3 Printed Material

Basic/State-of-the-Practice

Print materials are durable, portable, and highly accessible to nearly any type of traveler, at all travel stages. Traditional print materials include: 1) a system map that shows the alignment of an agency’s transit routes; 2) a route map that shows the alignment of an individual transit route; and 3) the schedule or timetable that provides the timing information for an individual route. Federal Accessibility Guidelines require transit agencies to provide print materials in a format that accommodates people with disabilities. Such formats include large print (at least 16 point font), tactile maps, color coding, and Braille.

While print material is a standard element of transit agency wayfinding assistance, many people find printed information aids like maps and schedules extremely difficult to use (Center for Urban Transportation Research, 2008). The lack of standardized map icons from one transit agency to another presents problems in quick understanding of printed transit wayfinding materials, especially for those unfamiliar with the system they select to take or are considering using. An additional limitation facing print materials is the probability of information being quickly outdated after publication.

State-of-the-Art/Future

The common use of personal computers and the proliferation of mobile devices with Internet and information processing may reduce, but will not eliminate, the demand for print materials. Through the practice of making more information available on transit websites, transit agencies have looked to reduce their printing costs. Many agencies now print and distribute significantly fewer maps and schedules than a decade ago. Individuals who do not have access to computers or mobile devices will continue to rely on printed materials for up-to-date information.

Related Elements

Information content: Station/stop, route, schedule, and fare.

Information format: Map, table, and text.

Information delivery media: Printed material.

1.3.4 Customer Service Centers (Telephone)

Basic/State-of-the-Practice

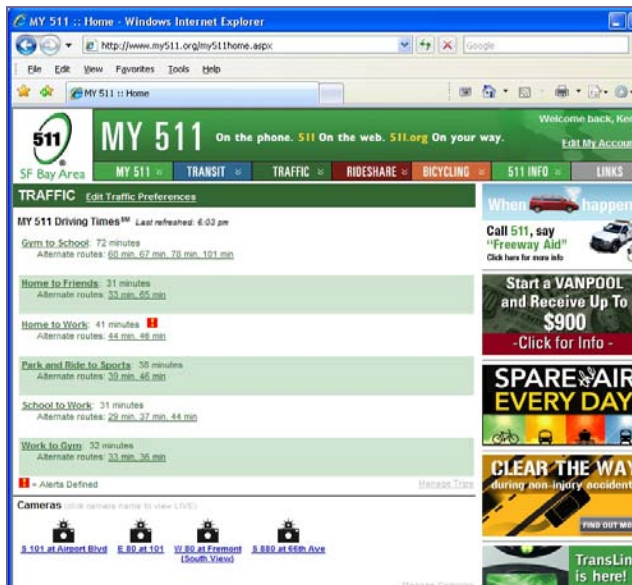


Figure 13: San Francisco Bay Area's comprehensive 511 website

Customer service centers are staffed with personnel who handle incoming calls relating to trip planning and/or customer service issues. In addition to agency specific customer information numbers, "511" has been designated as the sole travel information telephone number for states and local jurisdictions across the country. While some 511 services are specific to a single mode, others are comprehensive. The Metropolitan Transportation Commission in the San Francisco Bay Area has implemented a comprehensive 511 system that provides up-to-the-minute information on traffic conditions and incidents, details on public transportation routes and fares, instant carpool and vanpool referrals, bicycling

information and more (5-1-1, 2009). Transit information is also frequently provided via “311” numbers for comprehensive city services, particularly where the transit agency is a branch of the municipal government.

State-of-the-Art/Future

Despite the proliferation of non-telephone methods to access traveler information, transit agencies have seen little change in customer service call volumes, underscoring the continued importance of telephone services in information delivery. Agencies are increasingly utilizing voice recognition technology to implement interactive voice response (IVR) systems. IVR enables agencies to automate queries previously handled by agents. This can dramatically decrease caller hold times and makes information accessible 24 hours per day, 7 days per week.

Related Elements

Information content: Station/stop, route, schedule, fare, service alert and real-time location.

Information format: Electronic message.

Information delivery media: Human assistance.

1.3.5 Signage

Basic/State-of-the-Practice

The use of static signage provides en-route and at-station traveler information on a widespread basis at transit systems around the world. System signage has been commonplace since the inception of public transportation.



Figure 14: Chapel Hill Transit DMS (source: NextBus)

Agencies use electronic signs and video monitors to provide customers with transit service information. Dynamic messaging signs (DMS) provide information that increases customer convenience. Intelligent Transportation Systems (ITS) summary deployment statistics from 2006 indicate that roughly 30 percent (30%) of transit agencies in 29 large metropolitan areas surveyed use DMS in locations other than vehicles to disseminate transit routes, schedules, and fare information to customers (RITA, 2007a). DMS, such as light-emitting diode (LED) and liquid crystal display (LCD) systems, show train destination, arrival, and departure information. When placed on loading platforms, they may flash to alert riders of an oncoming train or bus.

Agencies across the United States use DMS and LED/LCD monitors to communicate information to customers who are en route, on-board, or at-station. The use of DMS is more likely at heavy and light rail stations or bus depots than at bus stops; although dynamic signs are being introduced at major bus stops as real-time vehicle location information becomes more available. According to 2007 ITS deployment statistics, Alameda-Contra Costa Transit District in California utilizes DMS at 75 of its 6000 bus stops. In contrast, the Bay Area Rapid Transit uses DMS at all 46 of its rail transit stations and is planning for the installation of in-station LCD screens to increase the type of information travelers receive (Moore, 2009).

Challenges to the widespread deployment of DMS, in addition to capital and operating funding challenges, include issues related to procurement, testing and implementation, operations, and maintenance, especially at extensive bus stop networks. Because real time scheduling is difficult to calibrate, some agencies have had problems with providing fully accurate next vehicle arrival information to be displayed on their DMS. Concerns specific to the use of DMS units include provisioning a steady power supply to signage, which may require extensive staff time and potentially complex interagency coordination. Additionally, transit agencies must account for the possibility of vandalism to DMS units at nearly each step of the project planning process, which often decreases the feasibility of such systems (Schweiger, 2003).

State-of-the-Art/Future

Remote Infrared Audible Signage (RIAS) or “talking signs” provide a signage system for blind, visually impaired, or cognitively or developmentally disabled transit users. RIAS consists of infrared transmitters that continuously broadcast directional information and spoken messages to wireless receivers carried by a user. The handheld devices relay station navigation or traveler information to a user via audio messages (Bentzen et al, 2007).

- RIAS has been deployed in a number of U.S. cities, at select transportation centers and buildings, as well as internationally in Canada, Italy, Japan, Norway, Scotland and

Turkey. RIAS has not yet become a widespread proven system. However, some of the U.S. transit agencies do currently operate RIAS technology in selected transit stations. These agencies include the Bay Area Rapid Transit (Powell Street Station and Fremont Station), San Francisco Municipal Railroad (selected stops), and Capital Area Transit Authority in Lansing, Michigan (on all buses). These agencies operate RIAS in support of a single mode of transportation (bus or rail).

- A demonstration of RIAS in the Puget Sound area is the first multimodal application that seeks to provide a seamless connection of signage among different modes (Talking Signs, Inc., 2006).

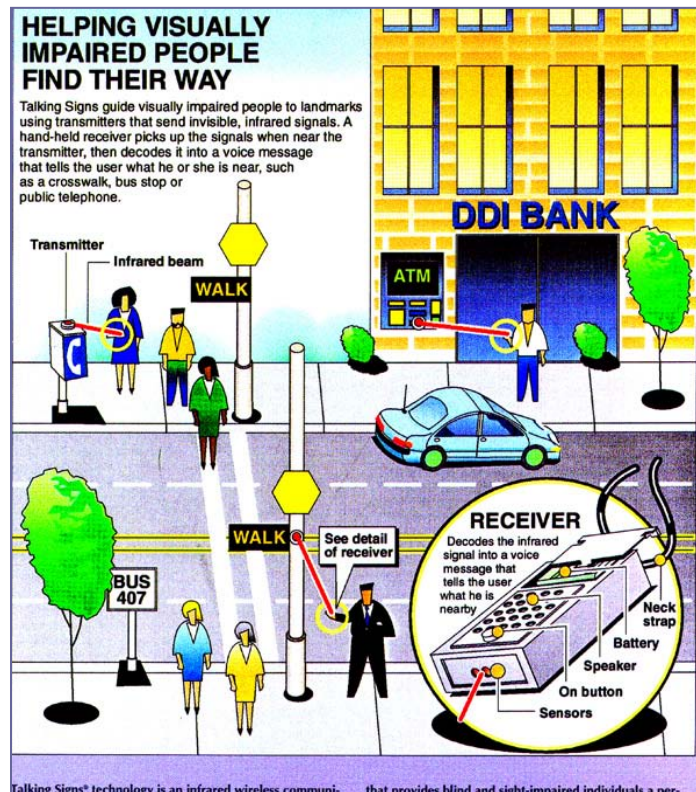


Figure 15: Description of a Talking Sign in Puget Sound, Washington

Potential challenges associated with the widespread deployment of RIAS systems include geographic scope and service population, which both impact the associated costs and benefits of system implementation. The effectiveness of a RIAS network is dependent on its comprehensive nature and on its ability to communicate seamlessly inside and outside of transit systems. RIAS networks are optimally provided in combination with other common public signage such as crosswalk and street signals and other directional aids. In addition, the potential size of the visually impaired or cognitively disabled community benefiting from a RIAS network must be commensurate with the associated system deployment costs (FTA, 2009a).

Electronic paper display (EPD) technology is an electronic sign capable of presenting text and images on a flexible surface that can be changed over time. EPD does not use a large

amount of electricity. The technology has been in commercial use worldwide since 2005. It appears in electronic books, cell phones, electronic billboards and other general signage. EPDs are touted for their superior readability and extremely low power consumption, compared to traditional LED DMS or LCDs.

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

Related Elements

Information content: Station/stop, route, schedule, fare, service alert and real-time location.

Information format: Text, electronic messages, static signage and electronic signage.

Information delivery media: Signage, public announcement, and mobile device.

1.3.6 Public Announcement

Basic/State-of-the-Practice

Public announcement systems, at-station or en route (in-vehicle audio messages), provide customers with a wide range of traveler information. Visual DMS often complement audible public announcement systems. 2006 U.S. ITS deployment statistics indicate that 26 of 236 transit agencies surveyed, or 11 percent (11%), use audible enunciators to disseminate transit routes, schedules, and fare information to customers. An even greater percentage of agencies providing rail service utilize public announcement systems (RITA, 2007b).

State-of-the-Art/Future

Automated Text-To-Speech (TTS) systems at the station or in-vehicle, convert spoken language by synthesizing pre-recorded spoken phrases stored in a database, or typed messages into spoken announcements and delivered over loud speakers. TTS systems are considered to provide more accurate and clearer messages, and at a faster rate than possible by human operators. Examples include:

- La Societe de Transport de Montreal uses a bi-lingual TTS system available in Canadian French or English (Business Wire, 2009).
- Bay Area Rapid Transit has used a TTS system for nearly a decade to provide at-station traveler information to customers (BART, 2009c).

Portable public address systems provide opportunities for increased communications with transit customers during emergencies or special events management. Similar to the hand held devices used by emergency responders, portable public announcement systems allow for hand-free use, and are considered superior to megaphones, because they allow operators to see in front of them. Portable announcement systems also provide traveler information in the case of power failures or other equipment malfunction. An example is:

- In 2007, the Dutch Railway system acquired 110 units as a means to improve transit safety operations. The public address units, which are powerful enough to reach hundreds of people in a crowd, can provide directions for customers during accidents or other significant events (InAVat, 2007).

Related Elements

Information content: Station/stop, route, schedule, fare, service alert, real-time location, destination, vehicle load factor, and emergency alert.

Information format: Live voice, electronic messages (TTS or recorded voice).

Information delivery media: Fixed or portable loud speaker.

1.3.7 Personal Computer

Basic/State-of-the-Practice

The 2003 U.S. Census indicates that 62 percent (62%) of households had personal computers, and 55 percent (55%) had Internet access.⁴ At the basic level, personal computers are most often considered networked to the Internet and stationary. Information of every sort is accessed through personal and laptop computers. Transit travelers may access pre-trip or, if wireless networks are available, en route information to accomplish a multitude of tasks related to trip planning. Customers may check transit schedules, fares, trip alerts, purchase tickets, and plan further travel.

According to 2007 ITS Deployment Statistics, 100 percent (100%) of the 193 agencies interviewed use Internet web sites to disseminate transit routes, schedules, and fare information to the public (RITA, 2007c). The personal computer and related electronic devices, such as cell phones, personal digital assistants (PDA), and smart phones will continue to grow as a significant method of accessing transit information. The use of personal mobile networked computers away from the home (cafés, restaurants, libraries, etc.) is growing as access to wireless networks, or Wi-Fi, expands into public and commercial space.

State-of-the-Art/Future

In choosing which digital services to provide, transit agencies must consider both the different degrees of customer informational needs (real-time arrival, multi-modal options, customized service alerts, etc.) and the varying methods that their customers access that information (telephone, mobile device, personal computer, etc.). Increasingly the line is blurred between personal computers and mobile devices.

A growing number of transit agencies around the nation (Bay Area Rapid Transit, Washington Metropolitan Area Transit Authority, Charleston Area Transportation Authority, King County Metro, to name a few) are equipping their buses and trains with Wi-Fi so that customers can browse the Internet, send email or even video conference during their transit trips. By offering Wi-Fi service, transit agencies provide additional amenities and convenience to their customers. Additional provision of web-based traveler information, including informational websites, real-time alerts, and advanced trip planning options, may increase customer satisfaction.

⁴ The 2003 U.S. Census 55 percent (55%) figure for Internet access has increased to approximately 73 percent (73%) of the U.S. population having access to the Internet (Wolfman Alpha, 2009a).

- In 2004, the Washington State Ferries system wired one of its oldest vessels, built in 1927, with Wi-Fi. Since then, the service has expanded to the entire system of 29 water transportation vessels, covering 8 counties and parts of British Columbia (Seattle Post, 2004).
- In January 2009, the Bay Area Rapid Transit initiated a 20-year contract to provide Wi-Fi to its entire heavy rail system (SF Gate, 2009).
- The Washington Metropolitan Area Transit Agency expanded or offered new wireless and cell phone services to its Metrorail service in February 2009 (WMATA, 2009b). The two most common models of wireless Internet deployment include free service, generally paid by the transit agencies, or subscriber based services provided by a private company in exchange for advertisement and user fee revenues.

Related Elements

Information content: Station/stop, route, schedule, fare, service alert, real-time location, destination, and vehicle load factor.

Information format: Text, website, and electronic message.

Information delivery media: Wired/ wireless personal computer, laptop computer, other mobile device.

1.3.8 Mobile Device

Basic/State-of-the-Practice

Current mobile devices, including cell phones, PDAs, and smart phones, deliver traveler information at all trip stages. These devices send and receive voice and data communication between a discrete device and a contracted service provider. These devices can be considered centrally networked because all communications are sent through a centralized provider (e.g. an Internet service provider (ISP), or a cell phone carrier for mobile device service). They do not generally communicate directly, device to device.

The use of non-networked devices is increasingly rare, but refers to *Palm Pilots*, *Sony Clies*, *Apple Newtons*, and *Apple iPods* (or, pre-*iTouch* or *-iPhone*) which are able to run programs, but are not able to connect to Wi-Fi or cellular networks. When such devices were popular, some agencies produced transit maps, and static schedules that could be downloaded via computer.

State-of-the-Art/Future

The potential to use mobile devices for purposes other than traditional calls or text messages is advancing at a rapid pace. Increasingly, mobile devices are being manufactured

to communicate between devices, or to read specially encoded data formats. These products are decentrally networked, because specific technology within the device facilitates communication transfers.

Future mobile devices will allow for complex data communications, including mobile transactions of electronic payments and ticketing, identity confirmation, or use as access keys for home/office, automobiles, etc. Mobile devices will be produced to interface with existing and new contactless reader technologies as a means to perform ordinary daily functions, many which will be specific to transit travel.

The issue of mobile device service coverage is a major consideration for transit agencies wishing to provide traveler information through mobile technology.

- In the United States, mobile device coverage in underground transit tunnels is limited.
- In contrast, Hong Kong's Mass Transit Railway has a full cellular network in place throughout the system of stations and tunnels.
- In 2005, the Bay Area Rapid Transit became the first US transit system to offer cellular communication to passengers on all wireless carriers on its trains underground (Cabanatuan 2005).



Figure 16: Quick response (QR) codes, a mobile device technology

One new mobile device technology is quick response (QR) codes—two-dimensional, matrix bar codes used to store information that can be decoded at high speeds. Originally designed for tracking parts in vehicle manufacturing, QR codes have been applied to commercial and shipping tracking applications and convenience-oriented applications aimed at mobile phone users. Japan is the leader in using QR coding to disseminate transit traveler information. There, QR codes appear as small images displayed at bus and train stations and deciphered by a QR reader enabled mobile device. Real-time vehicle location is combined with the QR code information to provide current location and arrival times of next buses and trains (Bournique, 2008). QR code information can also provide travelers with other site-specific information, such as local attractions and businesses, and links to informational websites.

Widespread use of QR codes is hindered by a lack of awareness of the technology both by the average traveler and by transit staff. There is also a need for a standardized QR code format. Presently, several QR mobile device reader formats are available, though none exists that will read all codes, requiring users to install several readers on one device. Without a common popular format (standard), mobile device manufacturers are reluctant to equip phones with any specific readers. Consequently, transit agencies will not invest in the network signage needed to effectively implement a QR system without a proven mobile device market presence (Bournique, 2008).

Near-field communication (NFC) is a new short-range radio technology for mobile devices. It allows for the transfer of information between mobile devices when an NFC-enabled device is brought in close proximity (roughly four centimeters) with another NFC-enabled device. NFC-enabled mobile devices operate between other NFC-enabled devices, and are compatible with existing contactless card systems used on mass transit networks (Accenture, 2009).



Figure 17: Near-field communications (NFC) enables mobile ticketing

The public transport authority of the Frankfurt Rhein-Main region (RMV) is one of the leading European transit agencies employing NFC technology. RMV's NFC mobile ticketing system allows for ticket purchase, verification, renewal and re-use or transfer. RMV is also expanding the use of smart tags installed at bus and train stops that are compatible with NFC-enabled devices to provide additional traveler information (Accenture, 2009).

Two important challenges to the widespread deployment of NFC technology include a need for standardization of the manufacturing protocol and a lack of existing complementary infrastructure to support the use of NFC-enabled devices in the United States. As of mid-2009, there is disagreement regarding the production method of NFC-enabled devices. Mobile handset device operators and device manufacturers differ on how NFC capabilities should be physically integrated into the device. Operators of mobile devices want the

technology to reside in the subscriber identity module (SIM) card, as opposed to the actual handset, so that the handsets can be exchanged without cost (a SIM card can be replaced without a complete change of the handset). Mobile device manufacturers prefer that the NFC technology directly interface with the handset in order to provide “added value” to the equipment. Currently, no clear business model has been proposed that would solve this conflict.

Europe and Asia lead the deployment of NFC applications specific to transit, partly due to the extensive existing contactless card systems in use there (Contactless News, 2009). The United States has been slower to adopt contactless card payment systems for transit, though the number of authorities considering the implementation of smart card systems is growing.

Major metropolitan areas with existing or planned contactless card systems include, Chicago, Phoenix, Dallas, New York, Boston, Ohio, San Francisco-Bay Area, Philadelphia, Portland, OR, and the District of Columbia (Smart Card Alliance, 2009). Yet, anecdotal evidence from recent interviews suggest that some agencies are waiting for the cost of these systems to fall and for the “lessons learned” to be revealed before embarking on their own system smart card implementation plans.

Recent research by the Federal Transit Administration has shown promising results for the use of personal GPS as a means to create more efficiency within paratransit systems. The study developed a prototype for personalized GPS units that, when combined with existing AVL systems, allow passengers and vehicle operators to know one another’s location. Additionally, a system’s agency dispatcher is able to see the location of both vehicles and passengers. It is expected that having location information provided at several levels will lead to more accurate or efficient pick up transactions between passengers and vehicles operators. Long term advancements for the use of personal GPS locators in paratransit systems include service vehicle reassignment to provide a more adaptable, economically efficient service, and technology upgrades that may include alarm notifications, voice recognition, and messaging service (FTA, 2009).

Related Elements

Information content: Station/stop, route, schedule, fare, service alert, real-time location, and destination.

Information format: Voice (by telephone), and electronic message.

Information delivery media: Mobile device and wireless laptop computer.

1.3.9 Transit Television

Basic/State-of-the-Practice - State-of-the-Art/Future

Transit television uses display screens to provide at-station or en route audio and visual information, entertainment, and advertising for transit riders. Several metropolitan areas, including Atlanta, Chicago, Los Angeles, Milwaukee, Orlando, and San Diego have deployed transit television networks as a means to disseminate information and garner advertisement revenue.

Pace, a suburban Chicago transit agency, provides transit television on buses throughout its system as a means to improve traveler experience. Each bus, depending on its size, incorporates two or three color screens that broadcast news, weather, sports, and other television shows at no cost to the customer (Pace, 2009). The Los Angeles County Metropolitan Transportation Authority reported that transit television advertisement revenue could amount to over \$100,000 in a good year for the agency (LA Times, 2009).

CBS Outdoor Network operates a successful digital LCD network to passengers on the Metropolitan Atlanta Rapid Transit Authority transit subway and rail systems. The system delivers CBS-based content, music, and traveler information and alerts (MARTA, 2009).

As of mid-2009, *Transit TV*, the largest private provider of transit-based television advertising in North America (including the systems mentioned above), had filed for bankruptcy while retaining ownership of the networks. The company manages 8,500 televisions, seen by more than 500 million transit riders annually, on nearly 4,000 vehicles (Torstar, 2009). However, the closing of Transit TV does not indicate that transit based television information and advertising systems are destined for failure. Market research shows that the recall or retention rates of advertisements of audio-visual advertising campaigns are high for transit television viewers (Carroll Media, 2009).

It is not inconceivable that some commuter routes may test more personalized TV systems, similar to what is offered by a number of airlines within the seat headrests. The transit agencies may see this personalized service as a revenue enhancement opportunity and an opportunity to expand their customer base, improving their competitive edge over other modes such as single occupant vehicle travel.

Related Elements

Information content: Stations/stops, route, schedule, fare, service alert, real-time location, and destination.

Information format: Audio, video, and text.

Information delivery media: Display screen.

1.3.10 Kiosks

Basic/State-of-the-Practice

Kiosks or interactive displays are computer portals that provide information to a user, generally associated with area amenities or other location services. Basic or state-of-the-practice kiosks provide non-networked or static information; this information is not frequently updated. Kiosks provide at-station traveler information to customers. Users access information through a touch-screen, a keyboard, a mouse, or a trackball. Combined with device applications like credit card readers, receipts printers, bar code scanners, or other identification devices, kiosks can provide a wide range of assistance to users.

Self-service travel kiosks are often connected to the Internet and may provide information and transaction services. Users may purchase and print tickets, check-in for or confirm travel, and access additional information on local attractions or weather forecasts. The benefits of interactive kiosks include the ease of use and access, decreased transaction times, and the ability to complete multiple transactions per visit.

In 2007, more than half of the metropolitan areas surveyed used kiosks to disseminate transit routes, schedules, and fare information to the public (RITA, 2007d). Examples of U.S. transit agencies of various sizes that use kiosks include:

- The Norwalk Transit System, a small municipal transit operator in Southern California uses kiosks at select transit centers to provide key destination and transfer information to travelers there (City of Norwalk, 2008).
- The Massachusetts Bay Transportation Authority has installed advanced kiosk systems equipped with keyboards, card readers, and printers at South Station, the largest train station and bus terminal in Boston that serves as a major intermodal transportation hub (Advanced Kiosks, 2005).
- In 2009, Miami-Dade Transit installed seven electronic kiosks at heavily trafficked Metrorail stations to provide information to existing and potential customers. A project survey to gauge the ease of use, accuracy, effectiveness, and perceptions show promising results for understanding user acceptance of the kiosks, and the information needs of travelers (FTA, 2009b).
- According to the Tri-County Metropolitan Transportation District of Oregon, challenges to the widespread deployment of interactive kiosks by transit agencies include high capital, operation and maintenance costs, and low user rates. Kiosks are considered useful at a limited number of strategic locations within a transit system, as opposed to spread throughout (Frane, 2009).

State-of-the-Art/Future

Interactive map systems are similar to kiosks, but provide users with an electronic map display capable of receiving specific instructions and responding to a user in a data format that can be transferred to a user's mobile device. These systems are able to display up-to-date information by drawing from Internet resources. The most recent example of this technology illustrates its use for providing at-station traveler information:

The Tokyo subway system recently launched a pilot project of an interactive map system at the Ginza station, a major transit intersection serving a popular entertainment and shopping district. The map is displayed on a 47 inch LCD monitor and assists travelers in finding specific destinations. The walk up touch screen provides travelers with an image of an area map. Links, or buttons next to the map feature local destinations like automated teller machines (ATMs), banks, and other services. Touching one of these buttons draws the shortest route to that location on the map. Additionally, users may enter addresses for other locations within the local area to access route information. The map system allows for the transfer of destination location to a mobile device that supports that technology. Users can turn on a map sensor that sends the information to a mobile device when held near the screen (PC World, 2009).



Figure 18: Interactive electronic map at Tokyo's Ginza station

Related Elements

Information content: Station/stop, route, schedule, fare, service alert, real-time location, and destination.

Information format: Video and electronic message.

Information delivery media: Display screen and mobile device.

1.4 Transit Wayfinding Technologies Summary

As noted throughout this chapter, wayfinding technologies are increasingly capable of providing real-time and relevant transit information at all stages of a customer's travel—pre-trip, en route, and at-station stages. With these advances in technology, transit agencies are thus increasingly moving toward information delivery at all stages. In particular, new technologies that allow for en route information support more flexible and real-time trip decisions and support dynamic mobility management by transit agencies.

Interestingly, the type of information transit agencies provide to customers has remained relatively constant, i.e., schedules, fare, destinations, service alerts. Yet, with the proliferation of systems that provide real-time vehicle arrival data or vehicle load capacities, the type of information available for display is expanding. When presented in combination, the information offers greater detail on status and conditions, which further supports trip decisions.

The design and the delivery of transit traveler information are also rapidly changing. In an effort to respond to customer needs, transit agencies are employing more technology based solutions to provide traveler information on-street, in-hand, and on-line. Further, transit agencies are exploring how to more efficiently and cost-effectively provide their customers transit-related and associated area information that may increase interest in the utilization of transit. Based on the interviews conducted and documents reviewed, the project team found that transit agencies seek a wider breadth of newer and less expensive traveler information technologies. Chapter 2 offers a greater illustration of these experiences.

Chapter 2. Wayfinding Deployments

The public and private sectors are rapidly advancing the state of the practice of wayfinding technologies. To explore how technologies are being developed, advanced, and implemented, the study team interviewed transit agencies, state departments of transportation (DOT), Metropolitan Planning Organizations (MPO), local associations of governments, commercial vendors, and application developers by telephone in the spring of 2009 (a full list of all interviewees can be found in Appendix C). Following telephone interviews, the study team selected nine metropolitan areas to conduct more in-depth discussion with these interviewees and expand interaction to additional regional stakeholders. Criteria for site visit selection included leadership and experience with the use of advanced wayfinding technologies and the potential transferability of their policies and practices. Site visits to nine metropolitan areas included the following:

- San Francisco Bay Area (May 2009)
- Portland, Oregon (June 2009)
- Seattle, Washington (June 2009)
- Chicago, Illinois (June 2009)
- Texas Metropolitan Areas: Houston, Dallas, and Austin (July 2009)
- Washington, D.C. (July 2009)
- New York City, New York and New Jersey (August 2009)

Appendix B offers a set of case studies that provide additional details based on each site's experiences. The case studies document the rationale for visiting, a site-specific "technology showcase" that highlights significant technologies in place in the region, unique challenges and lessons as well as recommendations to facilitate the growth of advanced wayfinding technologies. The technology implementations that were studied focused on a broad categories including real-time and static trip planners, web-based and cellular/mobile device interfaces, kiosks, telephone (voice) systems, with data sharing being an overarching issue that applies to all technologies.

Figure 19 on the next page illustrates the location of the site visits and phone interviews.

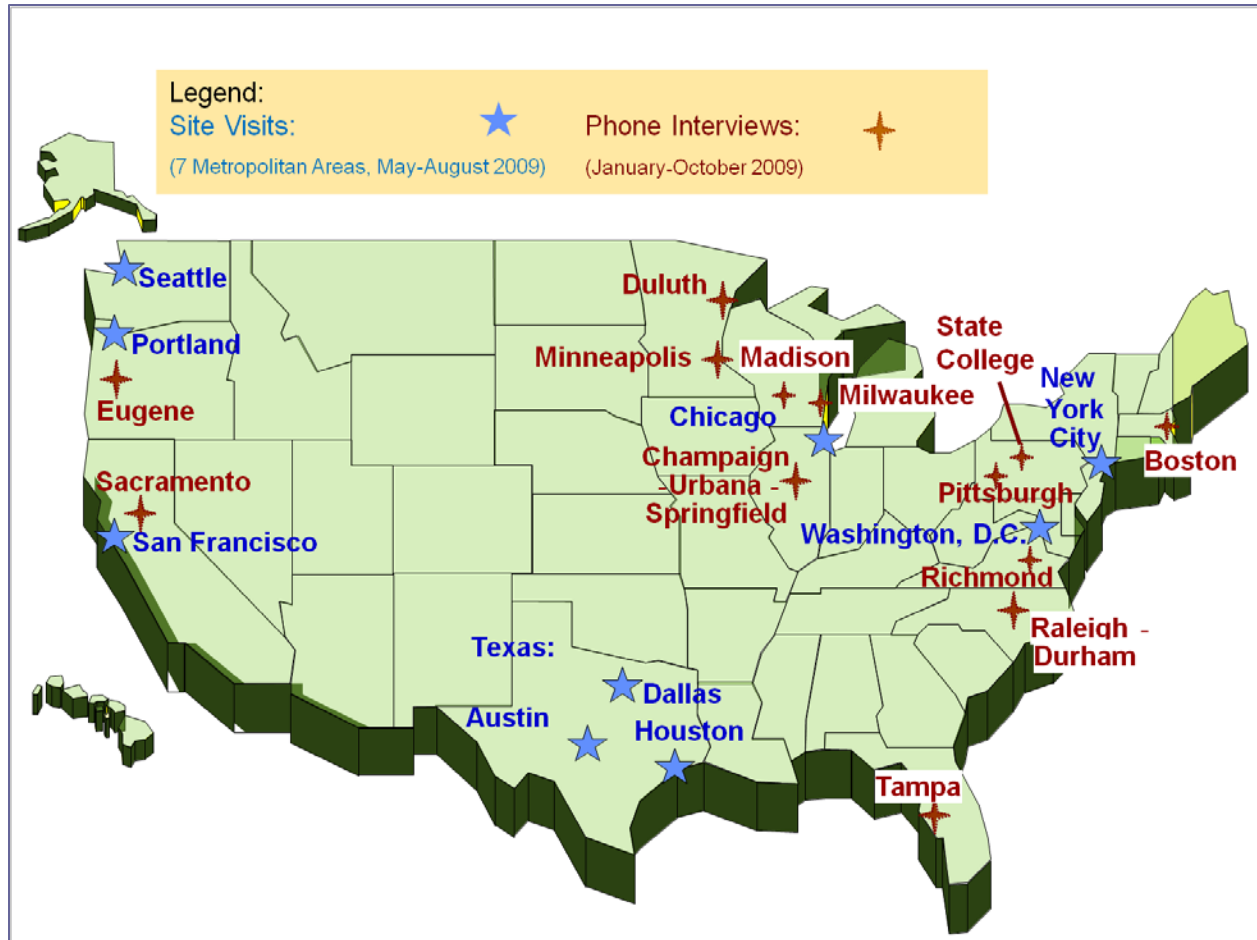


Figure 19: 2009 Wayfinding Technology Assessment Site Visits and Phone Interviews

2.1 Real-time Information

The provision of real-time data to customers is still in its adolescence as many transit agencies are still in the process of either considering, developing or implementing real-time information systems. While most agencies have real-time information for internal operations (a few still rely on radio communication for vehicle positioning), fewer release the information to the public.

The types of real-time data currently available from transit providers include vehicle location/arrival prediction and service alerts.

Arrival/departure prediction: Provision of real-time data to the public includes web-based maps showing vehicle location, next arrival displays at transit stops, and the development of web- and mobile-based applications. The most prominent of these methods are the first two, with many agencies providing data to customers. The development of mobile applications to distribute real-time information is still evolving as agencies wrestle with issues, such as sharing of real-time data (see challenges below).

Agencies that provide vehicle information on web-based maps include the Chicago Transit Authority (CTA) and Duluth Transit Authority, while many additional agencies provide real-time prediction arrivals either on the web and/or on displays at transit stops. Some of these agencies use private vendors to assist with some or all aspects of providing this information. For example, agencies such as Metro in Portland developed real-time capability in house. San Francisco Muni, on the other hand, relies on third-party vendors such as *NextBus* to install and maintain real-time systems, including developing prediction algorithms and data storage. Finally, some agencies rely on a hybrid of in-house development and third-party systems to provide real-time information to customers.

Agencies that provide their real-time data to the public enable third-party developers to quickly design and build applications and systems. For example, after the release of real-time data for BART trains, *Pandav*, a Bay Area developer, developed *iBART* for the *iPhone* and released it in two months. At the other end of the spectrum, when Dallas Area Rapid Transit (DART) decided to develop *Wheresmybus*, their real-time bus prediction service, delays due to legal concerns led to a development process that took over one year.

Service alerts: Transit agencies are also using social media to communicate with customers. The Metropolitan Transportation Authority in New York uses *Twitter* to communicate with customers about promotional events but does not post its information on transit service alerts. BART also has a Twitter feed, which allows it to send out information on delays but also special-interest stories to keep readers attention. Many agencies allow customers to sign up to receive service alerts by email and some by text message or cell phone.

2.2 Trip Planners

Trip planners generally rely on static data to help transit customers plan their trips. Most transit agencies have trip planners on their websites. Many agencies develop and maintain their trip planners, while others use third party trip planners, such as *Google Transit*.

The format of transit agency schedule data is one of the critical elements in a trip planner. Over the past several years, agencies have been working to convert their timetable data into the *General Transit Feed Specification* (GTFS). Some agencies, such as Dallas Area Rapid Transit, provide customers with both their own proprietary trip planner and *Google Transit*. However, agencies note limitations with *Google Transit*. For instance, the format limits the allowable maximum number of transfers; the format does not include some service information, notably accessibility options.

The latest innovation is the development of regional and personalized trip planners that extend beyond a single transit agency. In the Bay Area, the Metropolitan Transportation Commission is leading the development of a regional signage program that includes the installation of new static and real-time signs at transit hubs, where multiple agencies interact, easing transfer between systems. The Metropolitan Transportation Commission's regional trip planner, from the European firm MDV, combines schedule data from all Bay Area agencies so that users can plan a trip across agencies on one site. The agencies are responsible for converting their schedule data into the appropriate format and to update this data when schedule changes occur. The Metropolitan Transportation Commission also allows users to create a "My511" site, which allows users to see real-time departures for their transit itineraries, real-time traffic for their drive routes, and specific traffic camera feeds. This new service also has a phone and text message feature that allows users to bypass phone menus to access their trip information.

Trip planning for the mobility-impaired can help to shift paratransit customer to fixed-route services. Tri-County Metropolitan Transportation District of Oregon maintains an internal map-based tool that they use to provide paratransit trip planning assistance. The map features aerial photography, service boundaries, trip length, grade elevation degrees, curb cuts, a measure tool for distance, and the agency's ADA boundary, along with other planning elements that are required for the disabled community. The agency has plans to provide this tool to the disabled community for their use through their website and hopes the tool will help to encourage riders to use the fixed route system instead of paratransit.

2.3 Accessing Information: the Web; Cellular and Mobile Devices; Kiosks

While most agencies have web-based trip planners, fewer have interfaces specific to cellular and other mobile devices. This is one area where third party developers are leading, if the data are available for their use. In Austin, *Dadnab* developed a text-based trip planner that allows users to text a start and end intersection and returns a text message with an itinerary. *Dadnab's* service “scrapes” data from the transit agency’s web trip planner to retrieve an itinerary. Other developers use publicly available transit schedule data, for instance data available in *General Transit Feed Specification* format to plan trips. Still others have developed real-time signage using publicly available data to place in prominent locations where commuters gather, such as coffee shops.

The kiosk is also not forgotten in this new world of advanced wayfinding technology. At New York’s Penn Station, there are talking kiosks that feature a touch-activated, tactile map of the station, vivid visual displays for the partially sighted, and voice that provides phonetic clarity. As a customer touches different parts of the map, the kiosk describes the corresponding location and gives directions of how to get there. It also offers general information about Penn Station and the Long Island Rail Road. Similar to this, *Fd2s*, an Austin design firm, developed a kiosk and new wayfinding system for the Texas Medical Center in Houston that allows users to input their destination and prints out a detailed trip plan.

2.4 Data Sharing

While many agencies share static information with the public and third party developers, most agencies are not sharing real-time data with the public or third party developers. Tri-County Metropolitan Transportation District of Oregon is one of the first agencies to share schedule and real-time arrival data with developers and others who want to display the data. Bay Area Rapid Transit is another leader in providing agency data in an open source format that allows anyone to develop customer friendly interfaces.

The New York State DOT has been working for several years on an initiative to promote an open interface for data sharing between transit agencies. The initiative aims to improve operational efficiency by creating communications standards among agencies by allowing them to exchange transit operator schedule data at a regional level. The project uses open source tools to develop and support these information exchange methods. One outcome of the work is a specification for describing operator generated schedule data, called Schedule Data Profile (SDP). SDP can be used as a data repository allowing for the seamless exchange of data and the initiation of agency or regional software applications.

The Federal Transit Administration and the American Public Transportation Association have worked to develop and promote Transit Communications Interface Profiles (TCIP), through the USDOT's ITS standards development program. TCIP is a voluntary, modular standard which can be applied incrementally based on project needs. TCIP provides a standard approach to exchanging key information needed by information technology systems deployed by public transport agencies, supporting data sharing between agencies and vendors. TCIP is available online and hosts a family of user tools which have value in defining interface characteristics even if the standard is not specifically implemented.

American transit agencies, including LYNX in Orlando, Florida, have deployed TCIP-enabled traveler information systems and others, including some Canadian agencies, have listed TCIP as a requirement or alternate. Manufacturers have also developed TCIP product lines. For more information on TCIP, see http://www.standards.its.dot.gov/fact_sheet.asp?f=37.

2.5 The State of the Future

Agencies are currently working on a number of more advanced wayfinding technology solutions. These include the expansion of open source software and service oriented architecture software systems, open source multimodal trip planners, use of technology to switch from schedule-based to headway-based operations, and mashups, which combine existing data sources into new useful applications.

Open Source Software (OSS) and Service Oriented Architecture (SOA) software systems: OSS is computer software that permits users to use, change, and improve the software, and to redistribute it in modified or unmodified forms. SOA software is flexible and allows for interoperability between software applications, such that several organizations may easily integrate and use specific services as module applications. Moving towards OSS and SOA software systems allows transit agencies to transition away from proprietary systems. The use of OSS by Tri-County Metropolitan Transportation District of Oregon has cut service fees to \$18,000 from as much as \$45,000 annually. However, OSS and SOA applications are not always valid alternatives, and agencies should compare them to off-the-shelf software applications for their relative costs and benefits.

Open source multi-modal trip planner: An entirely new dimension of traveler information opens up for areas that have real-time traffic and transit data, where travelers are able to compare information across modes to find the best way to reach their destination. These trip planners can also provide travelers with accurate estimations of not only travel time, but also monetary cost and information on carbon emissions.

Tri-County Metropolitan Transportation District of Oregon is in the planning stage to develop a functional on-line prototype of an open source trip planner for Portland Metro that will incorporate walking, transit and bike modes. The project will also include an evaluation of the planner with a focus on the open source nature of the project, as well as the accuracy of the trips planned by the prototype. The objective is to create a successful open source version that is available to other transit agencies. The study will conclude in 2011.

In the Bay Area, the Metropolitan Transportation Commission is planning for the creation of real-time trip planners to allow travelers to compare travel times, cost and environmental impacts across modes throughout the region.

Headway-based operations: Agencies may begin moving away from schedule-based operations to headway-based operations. Real-time vehicle information at stops, online, and in users' hands (cell phones and PDAs) may negate the need for a schedule, freeing transit operators to run service more efficiently and effectively. San Francisco's Municipal Transportation Authority already does not distribute printed schedules, with little pushback from customers. With real-time information and a strong web presence, the agency is beginning to realize the savings of providing these systems. Additionally, by operating on headways instead of schedules an agency can better utilize signal priority systems without buses having to wait for a schedule adjustment.

Mash-ups: The development of "mashups" will create unique and new applications. One of these is the use of the *GraphServer* open source trip planner to display a "transit shed" on the *WalkScore* website. At Tri-County Metropolitan Transportation District of Oregon, the trip planner will feature location-based services such that if the search term, "Chinese restaurant" is entered into the planner, the planner will return all the available restaurant options along with a trip plan for using transit.

Chapter 3. Challenges and Recommendations

Chapter 3 summarizes the challenges and recommendations identified in interviews with public and private sector stakeholders regarding the development and deployment of advanced wayfinding technologies. The challenges include legal hurdles and institutional and technical issues that agencies face when building systems. Based on their experience, interviewees offered numerous recommendations on how others could proceed when considering implementing new technologies. This chapter also includes user needs in the development and deployment of advanced wayfinding technologies.

3.1 Challenges

The challenges in developing and deploying advanced wayfinding technologies transit agencies, local and state governments and third-party developers face fall into the following categories: communication, institutional, technological, and legal.

3.1.1 Communication

System roll-out: Communicating the deployment strategy of real-time systems to the public is critical to good customer service. Real-time arrival prediction accuracy is very important, and agencies need to clearly communicate with customers both the advantages and limitations of the new systems.

Internal agency departments: Communication is also important among agency departments, such as customer service, marketing, and Information Technology. Internal departments may have different goals and may not communicate those goals to each other. For instance, marketing might see an advantage to providing real-time data while operations, or management, may worry about on-time performance.

Accuracy versus speed: At Virginia Railway Express, the biggest challenge with real-time information is when and what messages to communicate. Regular customers, often upper-middle class and tech-savvy commuters, want service disruption updates and expect quick service delay notification.

Customer ability: In some areas, segments of the public may be more tech-savvy than the transit agency, leading to bewilderment among these customers as to why agencies are not providing what they consider basic information. In less tech-savvy areas, customers may not have access to or the ability to use advanced devices such as web-enabled smart phones.

Agency ability: Rural agencies, some with overlapping service, may not communicate and coordinate service, possibly a result of low staffing levels and service in remote areas.

3.1.2 Legal Challenges

While collection and internal analysis and use of transit route, scheduling, vehicle location, and ridership are standard practices for transit agencies, sharing that data with third parties including riders, application developers, and private partners is a relatively new practice with few direct parallels in other industries. Several common challenges described by agencies considering advanced traveler information and wayfinding systems are as follows:

Transit agency ownership of data: Ownership of transit data is a relatively new issue, which has emerged as consumers' expectations of access to information and quality of information have increased. Transit agencies have responded with a variety of approaches to information proliferation. Many small transit agencies, and a few notable large agencies, have taken steps to electronically proliferate route, schedule, and/or real-time location data in hopes that communicating accurate information to as many potential riders as possible will eventually increase ridership and improve customer service. Several other agencies have attempted to maintain tighter ownership over their data, believing they may leverage it to generate additional revenue through targeted advertising or data subscriptions to riders and/or third parties. In practice the former model has been proven more publicly acceptable, and a transit agency's right to ownership or control of transit data for financial gain has no legal precedent.

Vendor ownership of data: Many transit agencies have entered into agreements with private vendors to generate, analyze, and disseminate transit data to riders. In several cases, vendors have claimed their proprietary algorithms and prediction models have added additional value to the information transmitted to customers, and that their firm owns this value-added information. While several transit agencies have become involved in litigation over such information ownership, the majority of agencies have taken steps to define ownership rights in vendor contracts. To achieve maximum flexibility for future transit information products and services, transit agencies should seek to retain complete ownership of data through all stages of collection, processing, and dissemination. Vendors may wish to specify ownership of proprietary algorithms or processing techniques.

Control of data: Issues related to data control began during a period in which agencies published schedule and or route data online in HTML or PDF formats. Web or application developers seeking to use this information wrote programs to automatically extract, or "scrape," data. Transit agencies were concerned that 1) the automatic extraction programs would misinterpret or misrepresent official information, and 2) the transit agency would be liable to for incorrect information distributed by developers. Some transit agencies took legal steps to end the practice of "scraping" and met with varied success. As the state-of-the-practice has advanced, many transit agencies have opted to publish official feeds of information specifically for developers. In order to obtain access to data feeds, developers must agree to specific terms of use. Transit agencies must craft the terms of use carefully so that developers are held accountable for inaccurately transmitted information.

Third-party terms of use agreements: In addition to sharing data directly with end users and with individual and third party developers, many transit agencies have chosen to share information with *Google Transit* in order to distribute transit information to as many potential riders as possible. *Google Transit* has a Terms of Use agreement that transit agencies must agree to in order to participate in the free service. Washington Metropolitan Area Transit Agency, a notable exception, has declined to agree to *Google's* terms of use and has declined to publicly state a reason. Instead, the agency has publicly made available the data in the *General Transit Feed Specification* format but has released the data with its own terms of use agreement. However, *Google* has not agreed to the agency's terms of use; thus, Washington Metrorail and Metrobus are not represented on *Google Transit*. Similar issues can be anticipated with other third-party developers as the transit data landscape continues to evolve.⁵

3.1.3 Institutional Challenges

Common institutional challenges that transit agencies face is implementing advanced wayfinding solutions include the following:

Competition with operations and maintenance for limited funding: The concept of customer information as a part of service delivery is a new notion for some transit agencies. Operations and maintenance activities often overshadow the perceived need for advanced technologies to provide traveler information, especially if wayfinding projects are competing with basic operations and maintenance for limited funding. Furthermore, providing arrival information on transit routes characterized by frequent service is often considered a low priority with respect to other, often more pressing needs of a transit agency.

Lack of internal capacity to develop and maintain advanced solutions: Many transit agencies lack the resources or internal staff knowledge to develop advanced wayfinding solutions. Small transit agencies typically operate with limited Information Technology staff. These smaller staffs typically lack both the time and knowledge to develop advanced applications. In transit agencies that do have the internal capacity to develop solutions, budget limitations make it difficult to adequately train staff to keep pace with the continuous proliferation and advances in web-based and mobile technology. Without the ability to utilize internal staff, many agencies are often forced to rely on outside vendors and consultants to develop advanced wayfinding applications.

⁵ In July 2010, WMATA and Google signed a modified version of the standard GTFS agreement. <http://greatergreaterwashington.org/post/8993/google-and-wmata-signed-google-transit-agreement-in-july/>

Internal resistance to utilizing advanced technologies: Maintenance personnel and vehicle operators have expressed reluctance to utilizing new advanced technologies. Some operators dislike the use of on-board GPS trackers and their possible use for employee discipline. Maintenance personnel, especially more senior employees, are often hesitant of technology upgrades until the benefits can be tangibly demonstrated. When planning for and deploying new advanced technologies, agencies need to work closely with staff and explain why the technology is being deployed. In order to address the concerns regarding employee discipline, several transit agencies developed policies regarding how the technology can or cannot be used for employee discipline.

Incorporation of the Systems Engineering (SE) process into project management: The increasing use of technology solutions by transit agencies requires an integrated approach to technology planning and deployment that ensures the comprehensive design of and interoperability between complex systems. However, for many transit agencies such a Systems Engineering approach to technology deployment is the exception, not the rule. Traditionally, transit agencies have deployed technologies as standalone components, limiting the ability for systems to interact with other systems effectively.

Lack of regional coordination and cooperation: Coordination and data sharing between transit agencies that operate in the same region have been limited. Because of this lack of data sharing between agencies, transit customers have to access multiple sources, in order to receive complete wayfinding information for a region's entire public transportation system. This may be caused by technological challenges or by differing positions on technology policy. For example, larger agencies are more likely than smaller agencies to have legal and business concerns with *Google Transit* and are more hesitant to participate. In contrast, smaller agencies see *Google Transit* as a free tool to reach out to more customers. In a region where a large transit agency tends to dominate, smaller agencies may follow the larger agency's policy regarding data.

Wayfinding information and limited English proficiency population: Providing a trip planner in languages other than English is desirable, but may encounter cost constraints. Furthermore, engaging and measuring what particular communities expect and need in terms of wayfinding information is a challenge.

Capital funding programs provide little incentive to minimize cost: Capital funding schemes encourage agencies to purchase systems without an integrated approach, as there is little incentive to minimize costs. Introducing new technologies may offer many benefits to an agency; however, agencies need to consider long term maintenance and costs or be ready to face negative reactions from their customers if they have to discontinue the technologies. In many instances the reality of funding runs against the willingness of management and boards of directors to develop and implement new technologies.

3.1.4 Technical Challenges

Common technical challenges facing transit agencies implementing state-of-the-art wayfinding solutions fall into a number of categories: Data and Systems Integration, Global Positioning Systems, Data, Real-Time Data, Static Data, and Obsolescence.

Data and Systems Integration

- **Integrating data/systems from disparate departments and legacy systems:** Ensuring the interoperability of existing, out-of-date systems, and/or systems among different departments with new technologies can pose challenges. Altering data and/or systems to be compatible with new technology may dissuade vendors from taking on the risk of such work even if the agency is willing to move forward, driving up the cost.

An additional issue is the transition from one communication network to a more modern network, such as from the 800MHz radio band to digital radio network. Ensuring a homogenous method to smoothly transition the system may be difficult, as will the creation of performance metrics for the system. For example, measuring radio coverage will be difficult when there are known gaps in area coverage of cell towers. The adoption of new systems may also cause interference with existing radio communications, and agencies must consider this when choosing among ITS components.

Further, some systems have a tremendous amount of data that they could use to provide information to customers, but the amount of data may be too daunting for the agency to process. Additionally, system interfaces may not be able to handle the amount of data that systems may generate, for example real-time passenger load data from automatic passenger counters.

The above issues are relevant within a particular transit agency but grow when agencies begin to work together on a regional level. Differences in vendors, technologies, and data formats are a significant technical challenge if and when a region begins working on a multi-agency basis, for instance on a real-time trip planner.

- **Integrity of core systems:** Data integrity of the core rail and bus operational systems that produce customer information, such as the rail control system and the maintenance inventory database, is important. Inaccurate and/or non-normalized data cannot support reliable customer information systems.
- **Selection of ITS systems:** Agencies often have to choose between designing ITS in-house or seeking a commercially available off-the-shelf solution. Some agencies prefer application programming interfaces that are well-documented; however, not all vendors make these available. Additionally, some software installations require changes in business processes, yet these processes are organizationally difficult to update.

- **Naming of routes sometimes differs internally and externally:** Similarly, the naming of routes sometimes differs internally and externally. Many agencies have intricate naming systems for their routes, which may not be the same as the published route numbers. For example, an agency may have a specific name for a particular spur of a route that is input in internal operations systems differently than it is known to the public. Agencies may also run time-of-day variations of routes, such as skip-stop or express service that may not have a dedicated route number, leading to complications when developing interfaces between internal and external systems. When selecting or developing an ITS system, say for real-time arrivals, an agency (and vendor) must be fully aware of this issue.
- **Real-world testing is important:** Because software platforms are still maturing developers often use emulators, such as by developing the software for a cell phone by using a PC. There are issues regarding how standards are interpreted between platforms. Testing in the field is invaluable to see how software behaves in the real world.

Global Positioning Systems

- **GPS accuracy:** GPS accuracy ranges from within 3 meters to as much as 250 meters in the presence of tall buildings or other structures, creating significant challenges to operations and the provision of real-time arrival information to customers. For instance, bus stops may be closer together than the variance, or located nearby a layover area, making it difficult for an automatic system to determine whether a bus is arriving or laying-over for a longer period of time. To overcome this, agencies may build additional delay into their customer information system.
- **Multiple GPS antennae/systems:** Due to technical limitations, piecemeal funding, and issues related to vendor interoperability, several bus systems have multiple GPS antennae that each fulfill a different function. Some agencies expressed that this is not a major challenge and, in fact, provides a back-up in the event there is a GPS failure; however, maintaining duplicative systems is not cost effective.

Data

- **Standards:** The creation of data standards is essential to the integration between systems. Hardware standards are helpful, but data standards are harder to pinpoint. Often the development of data standards lags behind the development of new software. The development of standards as an issue applies to both real-time and static data.
- **Training:** Transit agencies may be overwhelmed by the new types and volume of data available and not know how to effectively use and store data.

Real Time Data

- **Automatic Vehicle Location (AVL) of buses is not always compatible with provision of real-time information:** The polling rate of vehicles is often too infrequent to be of much use for real-time predictions. Many agencies are only able to poll their buses every two to three minutes, which can lead to inaccuracy in real-time arrival predictions. Often there is not enough bandwidth available for transit agencies to transmit vehicle locations at a higher frequency, even if the on-board system can transmit at higher rates. Because of this issue, some agencies are wary about releasing real-time data due to the time lag. Some agencies have reported problems providing fully accurate real-time next vehicle arrival information. To overcome the time lag and real-time accuracy, calibration algorithms include extra time. For vendors, it is important that real-time information is as accurate as possible as it is in their best business interest.
- **Providing targeted real time information:** There is a desire to provide real-time service alerts on a stop-by-stop basis, especially in regards to inclement weather. In some parts of the country, microclimates may cause disruptions in one portion of a route or a broader area, affecting several routes, while in other areas service remains normal, creating a need to be able to differentiate the exact stops that experience the delays.
- **Email, Text Messaging and RSS feeds:** The delivery method, quality of message and willingness to pay for real time information are impediments to using these forms of information dissemination to customers. For example, Short Message Service (SMS) costs are high and prohibit this option for pushing information to customers. While it may be possible to charge subscription fees to offset the cost of providing SMS, user willingness to pay is not proven. Email notification of service disruption is possible, but necessitates a quality and timeliness to the messaging that is not currently possible for many agencies and consequently may not be an ideal solution. RSS feeds are another way to push delay information to users; however, some services delay RSS feeds. For example, there is a 30 minute delay for an RSS feed on Twitter, creating the potential for confusion and reluctance among agencies to use such methods.
- **Cell phone lag:** Cell phones are another tool that agencies can use to communicate with vehicles and customers. Sending real time location information from a cell phone to a server and back to another cell phone can take time, perhaps 10-30 seconds, and there is no tight bound on how long it takes. This can be an issue as agencies try to develop systems that alert customers on where to get off a bus: by the time the end user receives the message to get off the bus it could be a few bus stops late. Due to time sensitivities, it may be desirable to have applications that run on cell phones themselves. Location information comes from the cell phone's on-board GPS chip, and then an application makes the decision on when to give a command to the user, such as when to get off a bus. The only transmission of data over the cellular network may occur when the user first chooses the trip and the cell phone calls on the server to download the route and schedule. Limits on all this type of real-time system include the amount of

storage on the phone, for example mapping data. Additionally, the amount of usage of this and other types of systems can create a load problem on the servers which may negatively impact response times.

Static Data

- **Static data requires a “human touch”** - Static data often requires manipulation to be useful. Many agencies face this when converting their schedule data to the GTFS standard. For example, when converting data to GTFS some agencies may find that their data is not in a standard format, and that there may be hundreds or even thousands of small exceptions that need manipulation. Exceptions may include transfers/connections people can and cannot make. Real time data may be easier as the process could have automatic manipulation.
- **Data accuracy and connectivity:** Several agencies using the *General Transit Feed Specification* noted that not all connecting agencies participated. However, customers expect that *Google Transit* accurately represents interagency transit connections and transfers. In this situation, the tool may not accurately route travelers to train stations or connecting bus service.

Obsolescence

- **Equipment consistency:** Technology improvements may require wholesale upgrades throughout a system; for large systems that may be extremely problematic due to limited funding. Furthermore, if agencies introduce technology in a piecemeal manner, technology often changes so fast that the delay between the start of implementation and completion may be so great that when the project is finished, the original technology may be obsolete. This could result in a complex variety of equipment configurations that are difficult to manage.
- **Proprietary systems:** Agencies that acquire proprietary system require support from the original vendor, which may include many years of maintenance costs to keep systems up to date and support for data storage and retrieval. These systems may not be compatible with newer systems leading to duplication of equipment, for example, on-board GPS receivers. These proprietary systems may also be very costly to update or alter once contracts are in place.
- **Keeping up with changing technology:** Providing web-based wayfinding information is increasingly complex. Currently, there are several operating environments for mobile device platforms and internet browser requirements that require applications (i.e. website features, alerts etc.) to be developed in multiple standards. It is difficult for transit agencies, even those with highly competent information technology staff to keep up with the proliferation of different technologies and applicable standards. Furthermore, the need for certain projects that are in implementation programs (which

may take several years to finalize) may become insignificant as technology advances. For example, some question implementation of dynamic message signs when trends indicate that increasingly, transit information is received by personal mobile devices. Some agencies are taking a hands-off approach and are simply releasing their data, allowing the market to sort through the development of applications.

3.2 Recommendations

This study culminates with several important “lessons learned” from the interviews and site visits, as well as user needs in implementing and expanding advanced wayfinding technologies.

3.2.1 Lessons Learned

General lessons learned from the research and site interviews represent common sense approaches to project implementation. These include the following:

- Roll out real-time information systems slowly. It is important to iron out all glitches with data delivery, particularly real-time data, because providing inaccurate information can lead to customer frustration.
- Communicate transparently with the public regarding an implementation schedule and plan. Agencies may avoid public outcry if they are transparent regarding the implementation schedule and the testing process and careful to protect the testing website from public view.
- Position customer service information and interagency communications as security issues. Better customer service information and interagency communication increase the safety of transit operators and riders alike. Improved transit traveler information, coupled with targeted information sharing agreements between key public agencies, will enhance the comprehensiveness and efficacy of emergency planning and, ultimately, the successful outcomes of responses to actual emergency events by participating agencies.
- Use an interdisciplinary team to design and develop wayfinding systems to improve interoperability and reduce effort duplication. Include staff from IT, communications, customer service, operations, and maintenance in the planning and development of wayfinding systems to ensure the consideration and addressing a broad range of issues.
- Include an evaluation component into the implementation of wayfinding technologies to gauge the effectiveness of the project(s). Understanding how customers (both internal and external) use advanced wayfinding technologies and their benefits is essential to achieve optimal effectiveness and plan for future activities.

- Ensure buy-in from vehicle operators to ensure that equipment remains operational.
- Agencies should take care when developing requests for proposals (RFPs) and contracts with flexibility to keep up with technological advances and to make sure make sure they get exactly what they are expecting.
- States or regional governments can play an important role in assisting transit providers to develop and deploy advanced wayfinding solutions.

3.2.2 User Needs

In the interviews, agencies identified needs for technical and policy guidance and best practices in the areas of developing and deploying advanced wayfinding solutions.

- Agencies seek guidance on developing requests for proposals and contracts, including such items as data ownership, licensing, and vendor and technology decisions. Agencies particularly desired guidance on the contractual pitfalls to be aware of when working with vendors on wayfinding applications. Documentation of software and hardware configurations was also desired by transit agencies.
- Agencies are interested in data standards, particularly for real-time data. Some transit agencies and regional governments are developing real-time prediction standards, but would like to see federal guidance.
- Agencies require assistance with regional coordination on data sharing, particularly where agencies overlap each other.
- Agencies and regions need assistance in pursuing open source development.
- Agencies seek best practices with:
 - Delivery of customer information, including examples of transit agencies that meet the public standard of providing information.
 - Cost-benefit information for wayfinding technologies in relation to operational efficiency gains, customer satisfaction, and changes in ridership was also desired.
 - Policy guidance on positioning customer service information and interagency communications as security issues.
 - Guidance on data sharing, including legal guidance surrounding open data issues.
- Small and large agencies desire guidance on the use of *Google Transit* and the *General Transit Feed Specification*, including the technological, policy-oriented, and legal pros and cons of implementation and participation.
- Agencies seek to foster the use of standards among vendors and transit providers. Some agencies would like to see an open-source “ecosystem” in which to create technology

applications, including standards for open source data. Transit technology incubators, especially those that develop open architectures, were also desired.

- Agencies report that for some wayfinding equipment, European suppliers have highly desirable technology, but they are prohibited from purchasing these items, due to the “Buy America” regulations. They would like to see federal intervention to change these provisions and facilitate the purchase of products that encourage transit use, such as wayfinding equipment.
- Agencies want technical assistance and outreach to encourage use of ITS. This outreach is particularly desired by small and rural providers who may be disconnected from ITS-related discussions.

3.3 Conclusion

Draft findings from this 2009-2010 transit wayfinding and traveler information technology assessment were provided to FTA staff and proved instrumental in guiding a number of the activities included in the FTA’s ITS Research Plan – 2010-2014. Fifteen relevant transit wayfinding and traveler information projects are proposed, and their eight topics are below. A full description of these proposed projects as they appear in the FTA’s ITS Research Plan – 2010-2014, in Appendix C.

- 1) Inform Transit Investments Decisions in “Open Architecture” versus “Open Source” versus “Open Data” Approaches to Developing ITS Systems (3 proposed projects)
- 2) Integrated Corridor Management (ICM) Testing and Demonstration
- 3) Assess Transit Cyber-Security
- 4) Define and Assess “Real-Time” Data for Transit Operations and Multi-Modal Integrated Interfaces between Transit and Traffic Management (3 proposed projects)
- 5) Transit Spectrum Relicensing and Requirements Issues Identified and Guidance Development (2 proposed projects)
- 6) Investigate Role and Impact of Social Media Applications on Transit Agencies, including Mobile Devices
- 7) Special Population Needs and Uses of Technologies and Develop Accessibility Guidelines (2 proposed projects)
- 8) Barriers to ITS Adoption

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Appendix B. Wayfinding Deployments Case Studies

The study team selected nine metropolitan areas to conduct in-depth wayfinding technology discussions with a number of regional stakeholders. Study team site visits as part of the wayfinding technology assessment included nine key metropolitan regions:

- Chicago, Illinois (June 2009)
- New York City, New York and New Jersey (August 2009)
- Portland, Oregon (June 2009)
- San Francisco Bay Area (May 2009)
- Seattle, Washington (June 2009)
- Texas Metropolitan Areas: Houston, Dallas, and Austin (July 2009)
- Washington, D.C. (July 2009)

The seven wayfinding deployment case studies⁶ provide details from each site visit including the rationale for visiting, a site-specific “technology showcase” that highlights significant technologies in place in the region, unique challenges and lessons as well as recommendations for actions that the FTA can take to help facilitate the growth of advanced wayfinding technologies.

These metropolitan regions were selected based on their leadership and experience with the use of advanced wayfinding technologies, as well as the potential transferability of their policies and practices. Interviews were conducted with transit agencies, State Departments of Transportation (DOT), Metropolitan Planning Organizations (MPO), local associations of governments, commercial vendors, and application developers in each region. These visits enabled greater learning about the use of advanced wayfinding technologies (especially mobile applications) and their implementation opportunities and challenges.

Each site visit summary includes the reason for visiting, a site-specific “technology showcase” that highlights significant technologies in place in the region, unique challenges, opportunities and lessons learned. These case studies also provide recommendations for actions from each transit agency’s perspective that the FTA can take to help facilitate the growth of advanced wayfinding technologies. The input provided from the individual interviewees and agencies has been included within the overall summary in Chapters 2 and 3.

⁶ The team visited nine metropolitan areas, but the Houston, Dallas and Austin Metropolitan Areas are written together as a Texas Metropolitan Area Case Study, thus seven case studies are provided.

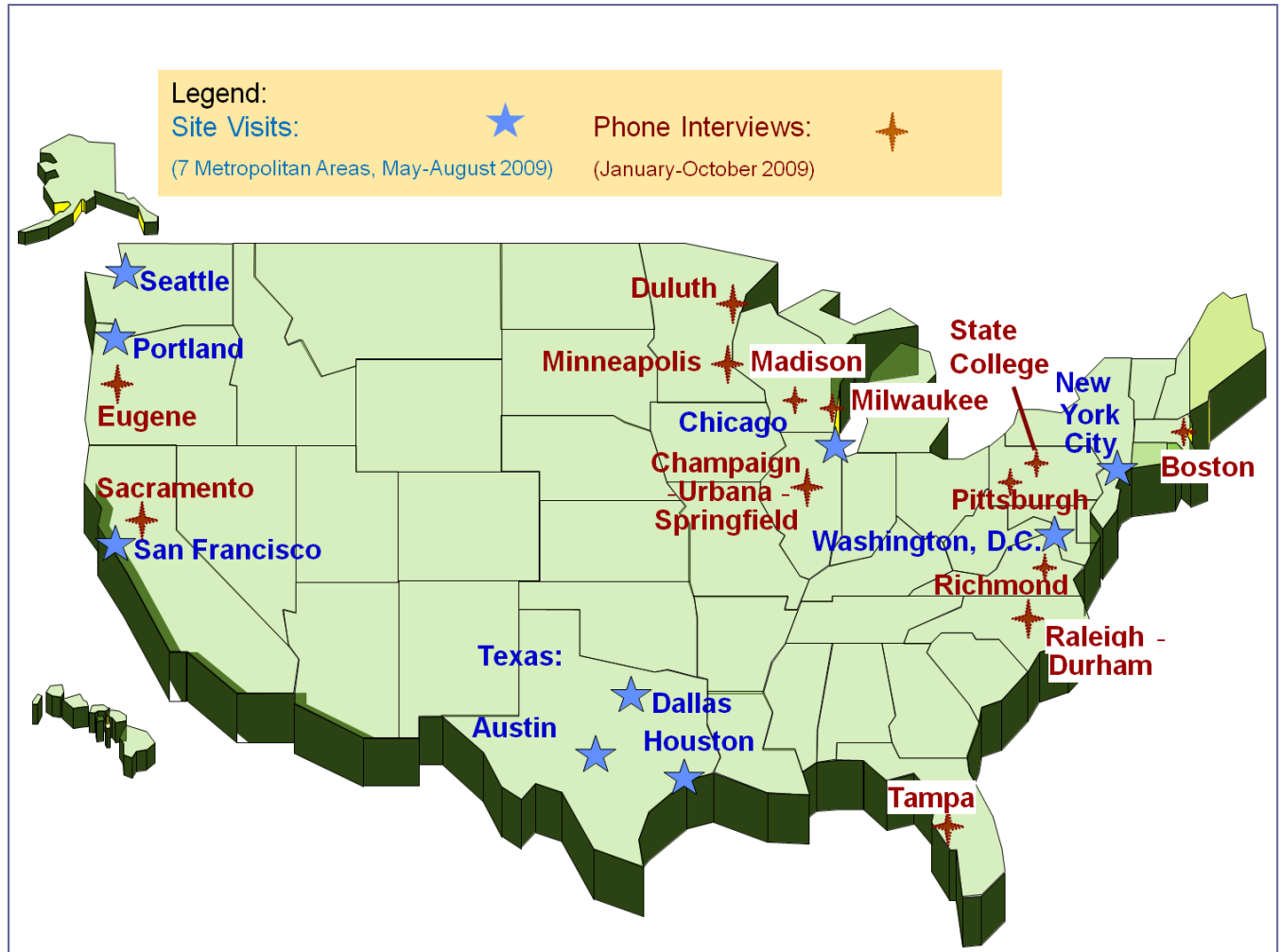


Figure 20: 2009 Site Visits and Phone Interviews

Chicago Metropolitan Area

Purpose for visit

The Chicago region is home to the second largest transit system in North America,⁷ providing more than two million rides daily. Chicago's regional transit system encompasses a six-county region with a population of approximately eight million people.⁸ The Chicago Regional Transportation Authority (RTA) provides financial and budget oversight for the region's three service providers: the Chicago Transit Authority (CTA), Metra Commuter Rail, and Pace Suburban Bus.

⁷ As measured by unlinked passenger trips.

⁸ Chicago Regional Transportation Authority: <http://www.rtachicago.com/aboutrta/overview.asp>

The following agencies were interviewed as part of the study:

- Chicago Regional Transportation Authority (RTA)
- Chicago Transit Authority (CTA)
- City of Chicago
- Illinois Department of Transportation (IDOT)
- Pace Suburban Bus

Technology Showcase

The following chart showcases the variety of technology in place at the various agencies and through private third-party vendors.

Table 4: Chicago Area Technologies

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Regional Trip Planner	Chicago RTA	<i>Goroo</i> : The region's web-based comprehensive decision support tool for choosing regional multi-modal travel options that considers convenience, efficiency, cost, real-time information, and the environment.
Real-time Bus Arrival Information	CTA	<i>Bus Tracker</i> : Uses GPS technology to predict real-time arrival of buses. Information is delivered to customers via the web (including a PDA-version), e-mail (by contacting customer service), or dynamic message sign (currently only one sign located at the Madison and Jefferson station).
	Pace	<i>WebWatch</i> : Uses GPS technology to predict real-time arrival of buses. Information is delivered to customers via the web and through a dynamic message sign (currently only one sign located at a major transit hub).
E-mail service alerts	CTA	E-mail subscription service for notifying customers of planned changes to bus and rail service.
Bus Location Map	CTA	<i>Bus Tracker</i> : Uses GPS technology to track the location of buses. Shows real-time location of buses, available to the public on the web. Users can access a “street view” from the map and set an alert to notify them when a bus reaches a certain stop.
	Pace	<i>WebWatch</i> : Uses GPS technology to track the location of buses. Shows real-time location of buses, available to the public on the web.

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Interactive Maps	Pace	WebRoute : Interactive mapping tool that allows customers to view or print custom maps. WebRoute allows the user to examine a route or group of routes in a community, while adding points of interest including transit connections and facilities, and shopping and medical destinations.
Google Transit Trip Planner	CTA	Provides route and schedule information to <i>Google Transit</i> in the <i>General Transit Feed Specification</i> (GTFS) format.
	Metra	Provides route and timetable information to <i>Google Transit</i> in the <i>General Transit Feed Specification</i> (GTFS) format.
Traveler Information Center	RTA	Call-in center, includes both live operators and interactive voice response. Provides information for both CTA and Pace.
	CTA	Live operators provide transit information, including real-time bus arrival information.
Static Wayfinding Standards	RTA	Developing standards for regional static wayfinding, including iconology, signage, signage placement, schedule formats, static mapping, etc.
Private Third Party Wayfinding Applications	CTA Bus Tracker API	Unofficial API for the CTA. Enables developers to build applications that present CTA bus routes, schedules, and arrival predictions. http://chicagowiki.transitapi.com/Home/bustracker-api
	Chicago Bus Tracker Widget	An iPhone application that allows customers to view estimated arrival times for selected CTA bus route. Developed in two months using the Chicago Transit API. (http://www.apple.com/downloads/dashboard/transportation/ctabustrackerwidget.html)
	Commuting.in	Pulls live bus tracking information from CTA and automatically shows customers when the next bus will arrive at a stop. (http://commuting.in/chicago/about)

Background

Real-Time Information

CTA and Pace Suburban bus were among the early providers of real-time transit information. CTA's advanced wayfinding capabilities are the result of an iterative process. Beginning with a foundation of AVL/CAD, the on-board systems now include GPS functionality to provide real-time bus information for both internal operations and external customers. In the future CTA

plans to continue building upon these systems to provide real-time information via electronic signs at bus shelters and via text messages, and eventually install video displays on buses.

Trip Planners

Numerous trip planners exist among the region's transit agencies. CTA and Metra provide data to *Google Transit*, and the RTA maintains a transit trip planner for the region. As a result of an RTA initiative, a new online, multi-modal, real-time trip planner that incorporates information from the region's three transit agencies, with driving and walking directions for the Chicago region has been developed. The RTA's "Goroo" online regional trip planner became operational in 2009.

Data-Sharing

While the transit agencies readily share static information with each other, neither CTA nor Pace currently shares its real-time data with each other or the public. However, in its contract with the real-time information provider, CTA ensures that the agency retains ownership of the real-time prediction data, and, therefore, may share both raw data and next bus arrival predictions with others. In the future, CTA plans to provide its real-time bus arrival information to RTA for input into *Goroo*, and is currently working with a vendor to develop a web API to facilitate this data-sharing of real-time location and prediction information. In contrast, Pace is limited in its ability to share such data because the vendor owns the prediction data under its current contract.

Challenges

Communicating with the Public

One of the greatest issues with transit wayfinding applications was the **prolonged time it took CTA to implement** its real-time system. CTA admits **poor communications with the public** regarding its process for implementing real-time information on bus routes. The two-year roll out of CTA's real-time information system was the result of introducing roughly five to 20 routes each month. The slow route-by-route roll out is a consequence of CTA's desire to ensure a high prediction accuracy rating for each of the routes added. The lengthy addition of real-time capabilities to the CTA routes resulted in public mistrust and dissatisfaction.

Institutional

CTA transit operators and maintenance personnel had to overcome a **technological learning curve** to implement advanced technology. Some staff were resistant to the technology upgrades until the demonstration of tangible benefits. While the CTA, as one of the nation's largest transit agencies, maintains a comparable technical staff, there are many agencies with small IT staffs and **limited internal technical knowledge**. These medium to small transit agencies often rely on outside vendors when attempting to develop advanced technology

solutions. The results are that rarely do these agencies have the **capacity to develop advanced solutions internally** or maintain them once they are in place, requiring further external contracts.

Legal

There is a great need for each agency or region to **develop a data sharing policy**. CTA is currently developing its formal data-sharing policy. The agency will share static data formally requested from the public; however the agency does not advertise this.

Intellectual property ownership, specifically of data, is a legal challenge that can result in open or closed access to the data collected and information supplied to the traveling public. Pace owns the underlying data, but not the algorithm to develop the real time prediction data. Therefore, Pace cannot share the real-time predication data. In contrast, CTA's contract gives it ownership of real-time prediction data enabling data sharing.

Lessons Learned

A **slow, steady, and deliberate rollout of real-time information systems** allows an agency to thoroughly fine-tune the data and improve arrival prediction accuracy. Before instituting such technology, clear and accurate geocoding of data is necessary for all transit stops and routes. CTA's 92 percent (92%) accuracy rate is the result of this approach.

The Chicago respondents advised that agencies should **utilize an interdisciplinary team to design and develop wayfinding systems**. The team should include staff from information technology, communications, customer service, operations and maintenance in the planning and development of wayfinding systems to ensure a broad range of issues are considered and addressed.

In addition, an **evaluation component** should be included in the wayfinding technologies implementation project. The evaluation enables a heightened understanding by the implementing partners how customers (both internal and external) use advanced wayfinding technologies. An evaluation also identifies any associated benefits, which are deemed essential to achieve optimal effectiveness. Lastly, an evaluation is critical for planning for future activities, not only by the implementing partners but for other agencies interested in following the lead of the implementing agencies.

User Needs

The Chicago interviewees highlighted two primary areas in which they could use assistance: (1) guidance on developing contracts, and (2) standards for real-time arrival predications. Regarding the former, the respondents would like to see a White Paper that outlines the contractual pitfalls to be aware of when working with vendors on wayfinding applications.

Regarding the latter, there is a need to understand how internal and external patrons use advanced wayfinding technologies and the specific benefits resulting in their use.

New York City Metropolitan Area

Purpose for visit

The New York-New Jersey region has an extensive and mature public transportation network, as well as multifaceted arrangements for interagency and inter-jurisdictional coordination. The complexity of transportation networks in the area requires wide-ranging organization between agencies. TRANSCOM, a regional coalition of 16 transportation and public safety agencies for the Tri-State region (New York, New Jersey, and Connecticut) facilitates a cooperative approach to regional transportation management. TRANSCOM's Trips123.org system provides transit information for New Jersey Transit (NJT), New York City Transit/Metropolitan Transit Authority (NYCT/MTA), and Port Authority Trans-Hudson Corporation (PATH), among other regional transit agencies.

MTA is the primary agency responsible for operating the city's subways and buses and two of its three commuter rail networks. NYCT and NJT are the largest transit agencies in the region. NYCT, a subsidiary of the MTA, manages the operations of the subways and buses throughout the city's five boroughs. PATH and the ferries, operated by the New York City Department of Transportation (NYCDOT) and private companies, play lesser but important connectivity roles in facilitating transit trips.

In addition to a multitude of transportation agencies, complex commute patterns also characterize the New York-New Jersey area, necessitating a variety of approaches to providing traveler information. For example, travelers may cross state boundaries, several regional jurisdictions, or use multiple transit agencies and modes in the course of their daily transit experience. New York City's public transportation system is among the oldest in the United States. The area has a strong transit culture where approximately 57 percent (57%) of New York residents utilize public transportation, (excluding taxis) for their commute.⁹ According to the NYC Department of City Planning, between 2000 and 2007, there was a significant modal shift in the metropolitan area from auto commuting to public transportation, resulting in an increase in NYCT) average daily ridership since 2003.¹⁰ However, with ridership growth comes

⁹ U.S. Census Bureau: American Community Survey (2005-2007). New York, New York County. Accessed, August 8, 2009, <http://factfinder.census.gov/>.

¹⁰ Changes in Employment and Commuting Patterns among Workers in New York City and the New York Metropolitan Area, 2000-2007. New York City Department of City Planning December 2008. Accessed 8/10/09 http://www.nyc.gov/html/dcp/pdf/census/census_commute_patterns0007.pdf.

certain customer expectations for more (i.e., several data formats, web, text, smartphone connections) and better (i.e., customizable, real time) transit traveler information. With its dense population and transit rich environment, the New York Metropolitan Region holds considerable opportunities for the proliferation of wayfinding technologies.

Agencies, government organizations, and developers interviewed in New York and New Jersey as part of this study were:

- FHWA New York Metropolitan Division
- Metropolitan Transit Authority (MTA)
- New Jersey Transit (NJT)
- New York City Department of Transportation (NYCDOT)
- New York City Transit (NYCT)
- Port Authority Trans-Hudson Corporation (PATH)
- The Open Planning Project
- TRANSCOM

Technology Showcase

The following table highlights the variety of technology in place in the New York-New Jersey region.

Table 5: NYC Metropolitan Area Technologies

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Trips123	TRANSCOM	Multi-modal traveler information system available on the web and by telephone: includes transit itinerary planner real-time information, and route-planning capabilities.
Real Time Bus/Subway Arrival Information	MTA/NYCT	<p>Real Time Bus Information: This project is a PLANYC Initiative to provide real time arrival information at selected bus depots, with tentative plans to expand the service city-wide. The project is called Select Bus Service and includes: automatic vehicle location, automatic passenger counters, customer information signs displaying “NextBus” information, on-line “Next Bus” information and “Next Stop” audio and visual announcements on-board the bus. Operations have begun at 126th Street Depot in Manhattan, and will soon expand to 3 or 4 more depots. Eventually, the plan is to install 360 customer information signs at bus stops throughout the city.</p> <p>NYCT has worked with three separate vendors to develop a network-wide real time bus prediction system. As part of the initiative described above, NYCT continues to work to resolve the technical issues involved.</p>
		Real time Subway Information: NYCT is installing DMS at 156 stations where subway tracking is operational. The project is expected to be complete by 2010.
NYCT Website	NYCT	Website Services: Trip Planner provides online and mobile interactive maps, walking time, fares, and general transit information. This service does not provide real time data.
		Service Alerts- email and text message.
		Maps and schedules- interactive map and static schedule.

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
		Public Announcement System provides service announcements-but no visual component.
NJT Website	NJ Transit	Website Services: Trip planner provides itinerary planning.
		Service Alerts- text, email, RSS.
		Maps and schedules- static data only.
"DepartureVision™"	NJ Transit	Real Time Train Information: This is a new service that displays train departure boards on mobile devices, such as iPhones, Blackberries or web-enabled cell phones. Customers can view train departure screens—including arrival time, track assignment and train status from their mobile devices. NJ TRANSIT is the first transit agency in the region to provide this service on mobile devices.
Twitter Alerts/ Updates	NY 511	Provides subway alerts from MTA and PATH websites.
NJT Bus Rapid Transit Project	NJ Transit	Automated fare collection
		DMS- passenger information displays at bus shelters.
		Cameras to enforce bus lanes.
Talking Kiosks	MTA and MTA Long Island RR	Installed at Penn Station and on the Long Island Rail Road concourse. Kiosk features a touch-activated, tactile map of the station, vivid visual displays for the partially sighted, and a voice designed for phonetic clarity. As a customer touches different parts of the map, the kiosk describes the corresponding location and gives directions of how to get there. It also offers general information about Penn Station and the Long Island Rail Road.
Television Displays	PATH	At platform television displays, sponsored by ABC Outdoor Television; providing limited traveler information.
Talking Kiosk-- Staten Island Ferry- St. George Terminal	NYCDOT/PLANYC	Provides station area information for Staten Island Ferry and St. George's Terminal. Overview information and direction and distance of particular destinations.

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Private third party trip planners	<i>Google Transit</i> -NY and NJ	Provides detailed transit trip planning itineraries.
	NYC Subway	Provides interactive subway map linked to MTA website subway line information. http://www.onnyturf.com/subway/ .
	Hopstop.com	Provides detailed subway, bus, and walking directions for 11 metro areas including: NYC, Metro North Rail Road, Long Island, and New Jersey.

Background

The implementation of wayfinding technologies in the New York- New Jersey region has made important gains in recent years, particularly in terms of the availability of internet information and data sharing. However, the lack of real time data available for the traveling public represents a sizeable gap in customer expectations for transit information.

Challenges to providing real time information at NYCT stem in part from the agency's historical legacy as three different railroad companies: the Interborough Rapid Transit Company (IRT), the Brooklyn-Manhattan Transit Corporation (BMT), and the Independent Rapid Transit Railroad (IND). In 1948, the companies merged to create the NYCT. These three companies had separate equipment and stations, deployed disparate technologies for signal systems, and different communication systems used to send and receive internal and external information. Each system operated by local communication with no central control platform, a condition which in part remains to this day, over 60 years after the merger. A 20-year old charge by NYCT to proactively monitor trains resulted in a central control center, which went live only two years ago (2008).

Through their agency websites, NYCT and NJT provide several transit wayfinding features. Additionally, NYCDOT and NYCT are planning to introduce bus services that incorporate elements of bus rapid transit, called Select Bus Service that will include advanced technologies for information dissemination. Coordination among the various entities planning new technologies and information based services will factor into the success of these efforts.

In the spring of 2008, NYCT completed an extensive transit signal priority (TSP) pilot program on Staten Island. Three hundred NYCT buses were equipped with TSP technology to interact with 14 signalized intersections along a 2.3 mile section of the Victory Boulevard corridor. The pilot

was found to reduce travel times along the corridor by approximately 17 percent (17%).¹¹ Though not considered a traditional wayfinding application, the project illustrates the willingness of NYCT to use technology to improve transit operations. Projects like TSP, when combined with traveler information technology, hold significant opportunities to increase transit ridership.

Real Time Information

NYCT has faced significant hurdles in the implementation of real time arrival information for subway and bus systems. According to the agency, there is public pressure to provide instantaneous transit information, but technological and financial challenges to providing it. As a result, NYCT emphasizes providing web-based traveler information as it works towards making real time arrival predictions available in the future.

A major challenge to providing real time transit information is due to the technological limitations of antiquated and separated legacy systems. Currently, only one-third of the NYCT subway system is centrally modeled, allowing trains to be tracked in real time. The remaining two-thirds of the subway system are still controlled by local towers, making real time information unavailable. However, NYCT is working towards making real time information available to its customers. The agency's long term plan is to expand train tracking technology, and to transfer that information into next train arrival predictions. At the 156 subway stations where tracking is operational (out of the total 468 stations), at-station dynamic message signs (DMS) will provide arrival time for the next two trains (to illustrate the regularity of service), including arrival information for different lines (i.e. 3, 4, 5), and information on special events or alerts. The project is expected to be operational on the (former) IRT line by 2010.

The IRT real time project does not address the related challenge of broadcasting real time alert information to customers inside subway stations. Currently, NYCT does not have underground antennas to allow for subterranean cellular communications. The size of the tunnel system and the complexity of its network make the task difficult. These reasons, coupled with the current economic environment, have dissuaded private companies from taking on the known and unknown risks of the work.

NYCT buses are not currently equipped with AVL systems for real time tracking and arrival predictions. Three separate attempts to deploy GPS based bus tracking in a pilot project along 2nd Avenue have been unsuccessful. Each company encountered various problems, including the canyon effect (lower GPS reception within a tall building environment) and interoperability issues with the agency's existing radio system. However, NYCT is committed to providing real time bus information for the anticipated bus rapid transit corridors. There, bus shelters

¹¹ NYC Transit Signal Priority Program Speeds Bus Service to Ferry Terminals. Accessed 8/15/09
http://www.govtech.com/pcio/277379?id=277379&full=1&story_pg=1.

procured for the project are equipped with space for a DMS, including a power source for operations.

Web-based Transit Information

There are a number of internet sources for transit traveler information in the New York-New Jersey region. The most well known itinerary planners that serve the New York area are: 511NY, Trips123, *Google Transit* and NYCT Trip Planner. 511NY and Trips123 offer multi-modal, multi-agency transit information for the metropolitan and regional statewide areas in New York, New Jersey, and Connecticut. These itinerary planners are similar but offer various levels of trip detail (i.e. transit conditions, incidents, construction, bicycle access, travel times, fewest transfers, fastest itinerary, preferred carrier, etc.) and inter-connections between transit providers. Using MTA schedule and station location data, *Google Transit* provides only New York City specific transit information. Since 2006, NYCT has provided a trip planner, the agency-built trip planning tool for bus and subway trips. Recently, NYCT used an in-house technical team to develop an interactive map to accompany the trip planner, in order to provide dynamic location based information to transit customers. The interactive map provides subway stops and information for nearby points of interest. However, the trip planner only incorporates the New York City subway and bus system, and does not currently interface with other modes or service providers (including the MTA Long Island Rail Road, MTA Metro North Railroad, etc.).

The proliferation of transit agencies using social networking sites and the addition of New York and New Jersey to *Google Transit* have increased the web presence of area transit information. New York was one of the last major cities to provide schedule data to *Google* in September of 2008 (*Google Transit's* program began in June 2006). The delay underscores issues related to sharing transit data for reasons including quality control, security concerns, and the potential monetary value associated with the content of the information.¹² Similar to the opinions of other large transit agencies interviewed as part of this project, NYCT continues to maintain its own trip planner to provide a level of service information, notably accessibility options, that *Google Transit* is not in the market to provide. Currently, 511NY manages Twitter updates for 24 NYCT subway lines and PATH trains. NYCT uses Twitter to communicate with customers about promotional events, but does not post its information on transit service alerts.

Data Sharing

At the state level, New York State DOT (NYSDOT) has been working for several years on an initiative to promote an open interface for data sharing between transit agencies. The objective is to improve operational efficiency by creating standardized communications among agencies to exchange transit operator schedule data at a regional level. The project uses open source tools to develop and support these information exchange methods. One outcome of the work is

¹² For a discussion of the profit potential of transit information see: MTA blogger defends iPhone app http://www.wtnh.com/dpp/news/new_haven_cty/news_wtnh_mta_blogger_defends_iphone_app_200908131200.

a specification for describing operator generated schedule data, called Schedule Data Profile (SDP). SDP can be used as a data repository allowing for the seamless exchange of data and the initiation of agency or regional software applications.¹³ Ultimately, the resource may be used to provide source data beyond transit schedules, (i.e. geographic information, real time information, etc.) to public agencies or private software developers that may use the data to develop applications that could potentially increase or improve transit traveler information.

Challenges

Institutional

The concept of customer information as a part of service delivery is a new notion for some transit agencies. Many times **operations and maintenance activities are pitted against providing transit information**. Operations and maintenance activities often overshadow the perceived need for advanced technologies to provide traveler information, especially if wayfinding projects divert funding from basic operations and maintenance. Furthermore, providing arrival information on transit routes characterized by frequent service is often considered a low priority with respect to other, often more pressing needs of a transit agency.

Historically, many NYCT technologies have been deployed as stand-alone components that did not require interaction between systems. The increasing use of technology solutions by NYCT and other transit agencies requires an integrated approach to project management that ensures the comprehensive design of, and interoperability between, complex systems. For many transit agencies **a Systems Engineering approach incorporated as part of the project management process is the exception, not the rule**. Systems engineering describes the framework of a system and its interactions with other systems, including how systems work together to provide specific services. The systems engineering process is particularly valuable in the development and operation of advanced technology projects associated with high costs and considerable risks. Project level guidance for using ITS architecture ensures that engineers from various disciplines (i.e. electrical, communications, etc.) understand the boundaries of their projects and where their expertise cross as a means to verify that components work together. Though a systems engineering approach may add to the upfront costs of a project, evidence suggests that when project requirements, stakeholders, risks, and other factors are identified from the beginning, overall project costs are lower, and ultimate project outcomes are better.

Technological

The New York respondents stated that providing web-based wayfinding information is increasingly difficult. Currently, there are several operating environments for mobile device

¹³ NYSDOT TSDEA Project Overview. October 12, 2006. Accessed 8/10/09
<http://oregonstate.edu/conferences/presentationsGOSCON/GOSCON-NYSDOT%20.pdf>.

platforms and internet browser requirements that require applications (i.e. websites, features, alerts, etc.) to be developed in multiple standards. It is **difficult for transit agencies**, even those with highly competent and trained information technology staff like at NYCT, **to keep up with the proliferation of different and evolving technologies and applicable standards**.

Furthermore, the need for certain projects that have been programmed for implementation (which may take several years to finalize) may become insignificant as technology advances. For example, some question implementation of DMS signs, when trends indicate that increasingly, transit information is received by personal mobile devices.

The New York interviewees noted that **ensuring the interoperability of existing or outdated systems (legacy systems) with new technologies pose challenges**. Within the MTA, many technology projects require major retrofits to the existing systems, which can dissuade interested vendors from taking on the risks of such work.

Legal

Traveler information systems in New York City have been stymied to some degree due to the **difficulties that older transit systems encounter in attempting to comply with federal regulations**. Federal regulations, such as the Americans with Disabilities Act (ADA), set accessibility design standards for transit systems. Older transit systems built prior to these regulations may face significant hurdles in meeting the ADA-compliant design requirements. Issues related to the placement of signs, the provision of equivalent audible announcements for every visual sign, and signage/letter visibility often require context specific solutions that many times add to project costs. For example, the ADA requires one inch of letter per 50 feet of visibility. In New York, some subway stations are constructed with curves. In these cases, the number of signs needed to meet the regulations make current deployment cost prohibitive or reduces the locations that signage can be deployed.

Ownership of transit data is an ongoing issue. Currently, the MTA is challenging the legality of the sale of a software application that was developed by a private individual using MTA Metro North schedule data. The MTA considers the activity of selling the software application a distribution of their train schedules without their explicit permission, and thus are seeking a profit sharing agreement with the developer.¹⁴ Other transit agencies make their transit data, including schedule data, available free of charge to the public. At the time of the interview in 2009, the legality of the MTA claim had not been determined.

¹⁴ MTA blogger defends iPhone app. Accessed 8/13/09
http://www.wtnh.com/dpp/news/new_haven_cty/news_wtnh_mta_blogger_defends_iphone_app_200908131200.

User Needs

The New York region interviewees highlighted four primary areas in which they could use assistance: (1) support for regional coordination, (2) best practices for customer information dissemination, (3) linking traveler information and communications to security issues, and (4) guidance on the ownership of transit data. Regarding data ownership, New York officials commented that as public requests for data and systems for collecting data increase, transit agencies need to understand the legal implications of sharing transit data.

They would also like to see earmark funding for regional coordination efforts to better focus these efforts. In the New York region, TRANSCOM provides an important coordination and communication role among transit and transportation agencies. However, when its members are distracted by uncertain funding obligations, TRANSCOM's status as a fee-based membership organization can detract from its efficiency as a regional planning body.

There were also requests to highlight best practices for the delivery of customer information and to position customer service information and interagency communications as security issues. The highlights should offer examples of transit agencies that meet the public standard of providing information. They should also illustrate the costs and benefits of wayfinding technologies in relation to operational efficiency gains, customer satisfaction, and proven increases in ridership. As part of the benefits from improved customer information, additional customer service information and interagency communication should increase the safety of transit operators and riders alike. Transit information improvements along with information sharing agreements among key public agencies will enhance the comprehensiveness and efficacy of emergency planning and, ultimately, the successful outcomes of responses to actual emergency events by participating agencies.

The State of the Future

Venues and technological applications for delivering transit information are proliferating daily, from the use of newly developed smart phone applications to pushing data out through the latest social networking website. In the New York-New Jersey area, the future of transit wayfinding will be driven by the transit user's expectation of instantaneous information, the established and growing software developer community, and the strong market presence of personal mobile device technologies from which to access, manipulate, and disseminate information. The following broad themes will characterize future expectations and opportunities in the transit wayfinding technology market in the region:

- Real time route information for all buses and subways (NYCT) will become a reality. Operating real time alerts on the IRT line and efforts to equip Select Bus Service with "next bus" information will drive the growth of this technology implementation.

- All transit agencies will provide better mobile information. With the provision of real time capabilities, the type and quality of information available to transit customers will increase.
- Greater integration of data between the transportation agencies will occur. NYSDOT's development of ITS standards like SDP will continue to foster data sharing and incorporation among state and local agencies.
- NYCT and other operating agencies will move toward greater integration of data between transportation modes. Trains and train stations will include bus information and vice versa, making clear intermodal connections between the modes.

Portland, Oregon

Purpose for visit

The Portland region has a distinguished reputation for leading in sustainable practices. In 1973, to protect the state's natural resources, a regional urban growth boundary was established. This initiative led to comprehensive statewide land use and urban planning goals, which necessitated the promotion and development of a more robust and expansive transit system. In 1986, the first 15-mile light rail line was constructed in Portland. Since then, the TriMet rail system has expanded into a network of approximately 52 miles, with several additional miles of expansion currently planned or under study.¹⁵

The area is home to a comprehensive system of buses, light rail, and bike lanes that promote alternative transportation, especially transit use. The Portland Metropolitan Area has seen rapid growth in transit infrastructure in the past two decades. According to U.S. Census data, in the City of Portland, approximately 12 percent (12%) of residents used public transportation to commute to work (34,451 out of a population of 282,782).¹⁶ Complementing the transit growth has been the increased implementation of transit wayfinding technologies. The use of transit wayfinding technology and the support for systems that support its development at the state, regional, and local levels position the area as a significant resource from which to learn.

Agencies, government organizations, and developers in the Portland, Oregon area that were interviewed as part of this study were:

- Metro Regional Government

¹⁵ TriMet, Accessed 08/10/09 <<http://TriMet.org/about/history/eastblueline.htm>>

¹⁶ 2006-2008 American Community Survey 3-Year Estimates. MEANS OF TRANSPORTATION TO WORK - Universe: WORKERS 16 YEARS AND OVER. Table B08301.

- Oregon Department of Transportation
- Portland State University– Oregon Transportation Research and Education Consortium
- Portland Streetcar
- Trillium Insight
- TriMet

Technology Showcase

The following table highlights the variety of technology in place in the New York-New Jersey region.

Table 6: Portland Area Technologies

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
TriMet Website	TriMet	Website Services: Trip Planner- An interactive online system map, utilizing real-time tracking of vehicles. Built on open source software, OS- PostGIS, OpenGIS, platform.
		Service Alerts- Include podcasts (video TriMet interest stories), Twitter, RSS feeds, email subscription alerts.
		TriMet Developer Resources - section of the TriMet website that promotes use of transit and information by providing developer specific information for access to schedule data and more.
Real Time Bus and Train Information	TriMet	Real Time Bus and Train Information: Transit Tracker - Real time arrival predictions for bus and light rail schedules. Service includes MAX, buses, streetcar, and shuttle service next arrival information.
DMS	TriMet	Use of signage to display estimated arrival time for next trains at all MAX line train stations.
Complete Bus and Train Stop ID system	TriMet	Every TriMet bus stop and rail station has its own Stop ID number. Each number is unique and may be up to five digits long. Customers can access stop ID information on the internet, or access next bus arrival via cell phone text alerts.
Kiosks	TriMet	Ticket sales and fare information are provided at each MAX station.
Wi-Fi	TriMet	Wi-Fi capabilities are provided on MAX line commuter rail.

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
TripCheck	ODOT	Transportation option planner--provides options- not itineraries for city to city travel for the State of Oregon. The website provides access to approximately 200 agencies trip planners, schedules, services areas, fare info, websites, etc. The transit information provided from TripCheck is static and not in real-time.

Background

Portland is the largest metropolitan area in Oregon, with a population of about 1.3 million people. Economies of scale, fiscal constraints, and potentially, transit rider demographics (i.e., a technically-savvy ridership that use the latest personal mobile devices) do support the widespread development of wayfinding technology applications. While TriMet is the agency responsible for the greatest deployment of transit wayfinding technologies in Oregon, efforts at the state, regional, and local level all support various aspects of the planning, development, and implementation of ancillary systems that feed into or support advanced wayfinding technology applications.

Statewide efforts

At the state level, transportation planning activities support the growth of wayfinding systems, and hold promise for broader multi-modal and multi-regional trip planning and information sharing among agencies in the future. The Oregon Department of Transportation (ODOT) develops and manages an application called TRIPCHECK in an effort to foster the dissemination of transportation information, including public transit resources on a regional level that cut across city and county boundaries. Implemented in 2007, TRIPCHECK provides road condition information and regional travel information. The transit portion of the website provides transit and brokered transportation options, but not city-to-city itineraries. The system links to the websites of public and private transportation agencies' trip planning information. The state would like to use technology like TRIPCHECK to better coordinate human service transportation. ODOT foresees this as a primary goal of the TRIPCHECK system in the future. Since transit markets have small service areas outside of the Portland and Eugene-Springfield areas, there are fewer opportunities to coordinate linking services or share agency-specific technology outside of these two main markets. ODOT staff also chairs TransPort, a regional ITS Committee, that in part reviews project (transit or otherwise) compatibility with regional ITS goals and infrastructure.

Regional efforts

At a Portland regional level, Metro, the Portland MPO, provides metropolitan planning for Clackamas, Multnomah and Washington counties and 25 cities in the Portland region. Metro

helps manage and coordinate ITS activities and planning among the members of the TransPort committee. A major charge of TransPort, and Metro in particular, has been to work towards the creation of a regional Transportation System Management and Operations (TSMO) plan (in draft as of fall 2009). The plan outlines ITS initiatives in relation to transportation systems management and travel options management, and sets forth goals and strategies for the successful implementation of a multi-modal transportation management proposal for the region. Specific to transit, the plan explains the functional overlap of advanced technology systems on the whole of the transportation network, namely transit signal priority (multi-modal traffic management) and real time transit information (traveler information), that may help to improve the traveler experience.

In addition, Portland State University's Portland Oregon Regional Transportation Archive Listing (PORTAL) system provides a single electronic database that collects, archives, and allows for the sharing of information among public agencies in the Portland-Vancouver region. Practitioners and academics have used PORTAL as a resource for creating arterial performance measures, developing long-range transportation plans, and freight management plans. Currently, the system does not collect transit data. However, past archived transit data from TriMet's AVL system was used to create a trip time model for scenario based planning (i.e., responding to specific questions such as, "What is the outcome on efficiency when boarding/alighting times increase based upon real time performance?"). The objective of the trip time model was to use the data to assist transit agencies in decision-making processes (i.e. where to site stations/stops).¹⁷

Local efforts

TriMet and Portland Streetcar (owned by the City of Portland, and operated and maintained by TriMet) are leading the way in the deployment of real time information systems and the implementation of both granular¹⁸ and customized advanced trip planning services. TriMet was integral to the development of the *General Transit Feed Specification* (GTFS). GTFS is considered an evolving, yet, prevailing practice that is in its infancy, the final development of which will be based on an iterative process between transit agencies and developers. TriMet was also the first transit agency to share schedule and real time arrival data with developers and others interested in displaying the content. Furthermore, a strong developer community that is pushing for the dissemination of public information has created a broad range of transit based software applications at virtually no cost to TriMet. This informal community of

¹⁷ In personal interview with Robert Bertini, ITS Lab Director, Portland State University. 7/16/09.

¹⁸ Granularity refers to the fineness with which data fields are sub-divided. Higher granularity refers to a larger number of data fields (for the same information) and requires greater memory for data storage and computation time for data input. However, a more granular database also offers benefits in flexibility of data processing in treating each data field in isolation if required. Scalability becomes an issue if a database contains excessive granularity.

developers paired with TriMet's open policy for facilitating sharing transit data have helped to strengthen the overall Portland area transit culture. From the developer community to the Oregon DOT, various activities have created a framework for implementation of transportation technology systems, specifically benefitted the deployment of advanced transit wayfinding technologies.

Real Time Information

TriMet uses a real-time bus arrival prediction system that provides information to riders at bus stops and light rail stations with a countdown in full minutes to the arrival of the next vehicle. All buses are equipped with on-board GPS units and in-track sensors for light rail. These tracking systems provide 90-second updates to dynamic message signs, TriMet's website, wireless access points (WAP), and phone-based systems. TriMet is in the beginning phases of installing a CAD/AVL system to be completed by 2012. The new system will include maintenance and operations functions and will generate better information for customers. For example, bus and rail operations will share location information, which will be available on TriMet's Transit Tracker. Additionally, last train/bus transfer protections will be built into the system to accommodate operations, so that a customer trying to transfer from an incoming vehicle does not miss the last train of the day.

Trip Planner

TriMet has developed an open source Online Trip Planner and Interactive Map for buses, light rail, commuter rail, and the Portland Streetcar. The TriMet trip planner provides step-by-step directions including boarding locations, fare information, and length of trip. The interactive map displays in traditional map and satellite views, providing a systemwide overview of connections between transit services and accessibility to destinations. A zoom feature provides granular detail including stop ID number, fare zone, city, next bus arrival information, other bus services at that location, and a link to a third party bicycle trip planner. Search options for the trip planner include location search (i.e., "library"), trip preferences like quickest trip, fewest transfers, shortest walk, and travel by train and bus, train only, and bus only. The next step for the planner will be adding real time location data to the display map.

Data Sharing

As previously mentioned, TriMet was one of the first transit agencies in the United States to freely share schedule and real time arrival data with developers and others interested in displaying the content. The agency was fundamental in developing and promoting the GTFS, which began as a means to obtain transit directions as fast as possible. The standard was developed specifically to facilitate the sharing of data among transit agencies and others. TriMet has been a stakeholder, and main contributor to the FTA-funded initiative to develop TimeTable Publisher - an open source tool that allows smaller transit agencies to generate,

amend, and verify scheduling data into readable, customer friendly timetables. The tool is designed to use data in the GTFS format for ease of implementation.¹⁹

TriMet endorses a policy of open data sharing and maintains a detailed “Developer Resources” page on its website to assist in the use and understanding of the available data. The consensus at the agency is that people are currently “screen scraping data” (pulling static data from websites and published schedules, which may be out of date). TriMet officials reason that providing accurate data to the public will promote the use of transit. In addition, transit agencies must comply with the Public Records Act, which maintains that public agencies cannot be exclusive to any one party. Therefore, the agency is obligated to make data publicly available for everyone.

Challenges

Institutional

An institutional challenge raised by the Portland respondents concerned the **difficulty in integrating information dissemination methods and technologies with Limited English Proficiency (LEP) populations**. Providing the trip planner in Spanish and other languages is desirable, but the feasibility is constrained by costs. Furthermore, it is a challenge to engage with a number of non-English speaking communities to understand their travel information needs and expectations, as well as measure the results from the wayfinding information provided.

Technological

Real-time information pushed to “subscribers” present challenges on delivery method, message quality, and the receiver’s willingness to pay for real time information. Short Message Service (SMS) costs are high and prohibit this option for pushing information to customers. Subscription fees could offset SMS costs, though the willingness to pay for such services is not proven. Providing planned or large disruptions via email or the internet, are possible, but necessitate a quality and timeliness to the messaging that is not currently possible. For example, there is a 30-minute delay on an RSS feed on Twitter. Pushing out emails is possible, but is cumbersome and not an ideal solution.

There is a desire to provide real time service alerts on a stop-by-stop basis, especially in regards to inclement weather. **Providing targeted real time information can be difficult**. Because of microclimates in the region, service may be disrupted in one portion of a route or a broader area, affecting several routes and not in another area (that is 5-10 miles away). There is a need

¹⁹ In person interview with TriMet, 7/14/09. and RITA, Accessed 8/16/09
http://www.pcb.its.dot.gov/t3/s080514_open.asp

to be able to differentiate the exact stops that are affected. TriMet is working to update maps for predefined inclement weather areas, such as snow or flood routes.

Migration of legacy systems and the creation of relevant metrics were technical challenges identified. Implementation of the new AVL/CAD system will require a migration from the current 800MHz radio to a digital radio network. Ensuring a homogenous method to smoothly transition the system will be difficult. Moreover, creation of performance metrics for the system, for example, measuring radio coverage, will be difficult when there are known gaps in area coverage of cell towers.

The creation and widespread adoption of data standards is essential to the integration between systems. Hardware standards have been helpful, though data standards have been harder to pinpoint. Often the data standards that have been developed have lagged behind the development of new software.

User Needs

Collection of best practices was one area identified by the Portland interviewees. In addition, they would like to see greater opportunities for networking, information about current innovative projects, and solutions to common transit agency problems.

The State of the Future

The Portland region is looking forward to a number of innovative wayfinding components and applications. These future items include:

- Open Source Software (OSS) and Service Oriented Architecture (SOA) software systems
- Open Source Multi-Modal Trip Planner
- Public roll out of the Mobility Map
- Enhancements to the TriMet Trip Planner
- Deployment of interactive mapping signs

OSS is computer software that permits users to use, change, and improve the existing software, and to redistribute it in modified or unmodified forms. SOA software is developed upon the flexible principles that allow for interoperability between software applications, such that several organizations may easily integrate and use specific services - built as module applications. Moving towards OSS and SOA software systems moves transit agencies from being locked into proprietary systems - often designed outside of the business processes of the agency. The use of OSS by TriMet has cut the agency's annual service fees to \$18,000, from a high of \$45,000. While OSS and SOA applications are not always valid alternatives, they should be weighed against off-the-shelf (OTS) software applications for their relative costs and benefits.

TriMet is in the initial planning stages of developing a functional on-line prototype of an open source trip planner for Portland Metro that will incorporate walking, transit and bike modes. The project will also include an evaluation of the planner, with a focus on the open source nature of the project, as well as the accuracy of the trips planned by the prototype. The objective is to create a successful open source version that is available to other transit agencies. The study will conclude in 2011.

Currently, TriMet maintains an *internal* map-based tool used to provide paratransit trip planning assistance. The map features six-inch pixel arterial photography (higher resolution than the widespread three-inch pixel version), service boundaries, trip length, grade elevation degrees, curb cuts, a measure tool for distance, TriMet's ADA boundary, as well as other planning elements that are required by the disabled community. The agency has plans to open access to this tool, named Mobility Map, and provide it to the disabled community for their use through the TriMet website. The tool will help to encourage riders to use the fixed route system as opposed to paratransit.

The TriMet Trip Planner will incorporate the real time location of vehicles for public utilization. In addition, the planner will feature location-based services for trip planning. If the search term, "Chinese restaurant" is entered into the planner, all the available options would be displayed along with how to plan a trip to the selected location using transit. En route to the restaurant, the transit patron will be able to use interactive signs. Interactive mapping signs, which are screens that depict the transit network and pertinent schedule and real time information, will be installed at strategic locations (based on the number of boarding's for that stop).

San Francisco Bay Area

Purpose for visit

The San Francisco Bay Area is home to Silicon Valley and is generally regarded as a hotbed of technological innovation. There are many transit agencies in the Bay Area, large and small, some of which have extensive experience using technology to provide information to customers. The complexity of interweaving transit services along with extensive technology use makes the Bay Area a unique case study for this project. Agencies, government organizations and developers in the Bay Area interviewed in May 2009 as part of this study were:

- AC Transit – Alameda Contra Costa Transit District
- BART – Bay Area Rapid Transit
- CalTrans – California Department of Transportation
- Google, Inc.

- MTC – Metropolitan Transportation Commission (MPO)
- Muni – San Francisco Municipal Railway
- NextBus, Inc.
- Pandav, Inc.
- PATH - University of California: Partners for Advanced Transit & Highways
- SamTrans – San Mateo County Transit District
- VTA – Santa Clara Valley Transportation Authority

Technology Showcase

The following chart showcases the variety of technology in place at the various agencies.

Table 7: Bay Area Technologies

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
511.org Regional Trip Planner	MTC	Multi-modal traveler information available through the web and telephone. Transit itinerary planner real-time information and route planning capabilities. The trip planner is sourced from MDV (vendor for Chicago RTA's regional trip planner). OTHER: Planning to have a clean API for other sites to use MTC's trip planner; SF Muni uses the MTC trip planner, saving redundant development costs.
Real Time Train/Bus Arrival Information	BART; Muni; AC Transit; NextBus; CalTrain	Using NextBus (AC Transit, Muni), ACS (SamTrans), or other proprietary or in-house developed (BART) predictive arrival technology to inform users of the next pending arrival(s) of vehicles. MTC is experimenting with multi-agency arrival displays at two stations. OTHER: AC Transit switching from NextBus to INIT systems; CalTrain currently has a project to install GPS on trains to provide real-time arrivals at stations. Current system is dispatch-updated signage.
BART Developer Website	BART	Static and real-time data is made available to anyone who wants to use it. http://www.bart.gov/schedules/develops/index.aspx Also includes a page dedicated to helping people put up displays of real-time train arrivals.

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Traditional Wayfinding signage program	MTC	Implementing standard, highly visible, Wayfinding signage at major transit hubs. Currently installed as a beta at Embarcadero.
New real-time train locator signage	Muni	Currently testing new real-time train location maps inside stations. Currently at Van Ness Station.
EDAPTS	CalTrans	Developed a pre-specified package of ITS software and hardware for rural agencies that lack the staff and funding to research, procure, and maintain systems independently by relying on off-the-shelf products.
GTFS	CalTrans	CalTrans is working with CCIT to help smaller agencies get their data into the GTFS format.
Open-source IT	BART	BART's IT runs on Linux, significantly cutting down on the cost of licensing, etc.
iBART	Pandav	IPhone application that was developed in two months time using GTFS BART data; similar program developed by an agency could take years.
My511	MTC	Developing a personalized trip and alert planning website. User can save settings and trips and go to one site to receive automatic planning and alerts.
Twitter	BART	Uses Twitter to interact with riders and provide alerts. Intersperses special interest stories with real-time alerts.
ITS Strategic Plan	VTA; AC Transit	VTA has lots of experience with ITS, having control over HOV lanes in Santa Clara County. They've developed an ITS Strategic Plan. AC Transit is just starting to develop a similar plan.
Technical Assistance Committees (TACs)	MTC	MTC has organized several TACs that are made up of representatives from local stakeholders to come up with solutions in a variety of areas, including data transmission specifications, information dissemination systems and static and dynamic kiosk design standards.

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Reliance on electronic schedules only	Muni	Muni no longer prints a paper schedule, relying on electronic formats and real-time information at bus stops.
3-1-1 provided transit information	Muni	San Francisco's 3-1-1 system now incorporates Muni's call center, whereby operators use NextMuni to provide transit information.
In-house developed code to convert Trapeze data to GTFS	Muni	Muni wrote their own code in about two weeks to convert Trapeze timetables into GTFS, saving \$40,000. Willing to share code with other agencies.
Dial-in for next arrival	SamTrans	With unique stop IDs, customers will be able to call in, enter the ID and receive next arrival information.
Train arrival information on highway DMS	SamTrans/CalTrain	In coordination with CalTrans, train travel times are displayed on adjacent Highway 101 if the train travel is faster than the expected drive time.
<i>General Transit Feed Specification</i>	<i>Google</i>	Began as a "20%" project, has become a standard format for transit schedules. <i>Google</i> worked with TriMet, who was the lead engineer on the project. This semi-open source data format can be changed by a "Change Group" which consists of agencies and developers. 120 agencies now provide data in GTFS format and about 20 release it publicly.
Multi-modal Trip Planner	<i>Google</i>	<i>Google</i> wants to create a multi-modal trip planner for <i>Google Maps</i> , which combines traffic data and real-time transit data to hopefully increase the competitiveness of transit.

Background

The Bay Area has a long history of innovative transit development. With a diverse geography and multiple economic centers, it is not surprising that agencies have taken different approaches to using technology to improve wayfinding. The abundance of creative talent, the adjacent technology hotbed of Silicon Valley, and world-class universities have all been factors that combine to produce a unique variety of transit wayfinding approaches. From the use of proprietary, private sector solutions to the embrace of the open source community, and even a mixture of the two, this microcosm of approaches presents a unique opportunity to study transit wayfinding.

Real-Time Information

Since the 1990s, transit wayfinding technologies in use have included the evolution of on-board AVL/GPS systems to providing real-time bus information, the provision of real-time train arrival information (BART), and on-line trip planners. Each of these systems was generally developed within an agency, with little external coordination and sharing of data with other agencies during the development stage.

Trip Planners

Regional coordination in wayfinding is one result of Regional Measure 2, passed in 2004, which “calls for better synchronizing of transit systems’ routes, fares, schedules and facilities.”²⁰ Through this mechanism, the MTC, the region’s MPO, leads the effort to regionalize transit on several fronts, including the creation of a regional trip planner, standard signage at transit hubs, and implementation of the TransLink single farecard payment system.²¹ This regional effort relies on the participation and coordination of the many agencies in the Bay Area via Technical Assistance Committees (TACs), made up of representatives from stakeholder agencies to make decisions and determine standards. These decisions include data transmission specifications, an information dissemination system and the design of kiosks.

Two projects of note are the regional 5-1-1 trip planner and wayfinding program. The MTC’s regional trip planner, from the European firm MDV, combines schedule data from all Bay Area agencies so that users can plan a trip across agencies on a single site. Each agency is responsible for converting its schedule data into the appropriate format and updating this data when schedules change. The MTC also allows users to create a “My511” personalized site, where users can see real-time departures for saved transit itineraries, real-time traffic for their saved routes, and saved traffic camera feeds. This new service also has a phone and text message feature that allows users to by-pass phone menus to access their saved trip information.

The MTC is also leading the development of a regional signage program that includes the installation of new static and real-time signs at designated transit hubs, particularly where multiple agencies interact. One of the primary components of this project is the development of unified signage standards including fonts, colors and other design elements. The regional signage should facilitate easier transfers between systems.

²⁰ MTC Transit Connectivity Plan, May 2006.

²¹ The Bay Area’s all-in-one, reloadable transit card is now known as the Clipper. Clipper is currently accepted on Muni, BART, AC Transit, Caltrain and Golden Gate Transit and Ferry, and will eventually be accepted on all forms of Bay Area public transit. For more information, visit <http://transit.511.org/translink.aspx> or www.clippercard.com.

Data Sharing

Research and development on mobile applications are also taking place in the Bay Area. By publicly releasing its GTFS and real-time data, BART allows the developer community to create new applications that allow users to get information on a myriad of devices. Pandav, Inc. is one such vendor, having created the iPhone application “iBART” in 2008. Today, iBART 2.0 includes real-time train arrival information. Anyone with an iPhone can pull up the next arriving trains on their itinerary. Other research is being done as part of Safe Trip-21, a federally-sponsored safety and congestion initiative, where cell phones are being tested as mobile traffic probes that simultaneously provide users with better real-time traffic information and potentially alternative transit information.

Challenges

There are many challenges to procuring, implementing and maintaining advanced wayfinding technologies, among them institutional, technical, and cultural challenges. The Bay Area, with its myriad transit agencies and abundance of technological resources, presents a good overview of the challenges facing other areas across the country.

Institutional

The Bay Area’s transit agencies operate largely independently, and the passage of Regional Measure 2 puts the onus on the MTC to bring all of these agencies together. The effort to **ensure broad cooperation between local and regional governments** is a significant institutional challenge. Even when cooperation is initiated, there are still the problems that **the goals of regional transportation agencies and transit agencies do not always mesh**. One transit agency may want to release and share all data between agencies while the regional body may seek to exert control over data availability.

Data sharing can be stymied by the lack of region-wide or state-wide standards. Decision-making requires the establishment of standards and are critical to good planning. For instance, as the state plans to implement high speed rail, data and technology interfaces across agencies will be necessary. Another factor in resistance to data sharing is that **the benefits of data sharing are not readily apparent**. Many agencies are reluctant to provide their timetable data in GTFS as they do not see the benefit of providing GTFS data. This reluctance is dropping, as more agencies do release data the benefits become clearer.

The Bay Area interviewees highlighted many **funding challenges**. Wayfinding and other advanced technology initiatives generate the need for **trade-offs and conflicts between the capital funding versus the operations funding**. Capital funding schemes encourage agencies to purchase systems without an integrated approach as integrated systems offer little incentive to minimize costs on the capital side. In addition, **funding realities can conflict with agency desires**. In many instances, the reality of available funds runs against the willingness of

management and boards of directors to develop and implement new technologies. Finally, introducing new technologies may offer many benefits to an agency; however, agencies **need to consider long term maintenance staffing needs and added costs** or be ready to face negative reactions from their customers if they have to discontinue the technologies.

The Bay Area respondents saw that many **rural transportation agencies lack ability to offer advanced wayfinding technologies**. In California and elsewhere, rural agencies may have overlapping service, but they may not communicate and coordinate service. This may be a result of low staffing levels and service in remote areas. In these same areas and including some urban communities, the **transit patrons may be more tech-savvy than transit agencies**, leading to bewilderment among customers as to why agencies are not providing what some consider basic information.

There are also internal institutional challenges to wayfinding applications. **Agency departments** (Customer Service, Marketing, IT, Operations) **may have different goals** and may not communicate those goals to each other. For instance, marketing might see an advantage to providing real-time data, while operations or management may be hesitant as they worry about on-time performance. Some agencies are concerned with how their data might be used if it is available to the public. **Bus and train operators may be reluctant to use on-board vehicle locators**. “Phantom” buses, those operating off the grid, are occasionally a problem, and management may have to intervene to ensure systems are operational. Additionally, workers can destroy equipment when they do not desire the system to be able to track them.

Technological

Proprietary systems require support of the original vendor: This may include many years of maintenance costs to keep systems up to date and support for data storage and retrieval.

Integration of systems and data: There is a tremendous amount of data available; however, system interfaces don’t necessarily take advantage of this data.

AVL monitoring of buses is not always compatible with provision of real-time information: The polling rate of vehicles is often too infrequent to be of much use for real-time predictions. Many agencies are only able to poll their buses every two to three minutes, which can lead to inaccuracy in real-time arrival predictions. One reason for this is that there isn’t enough bandwidth available for transit agencies to transmit vehicle locations at a higher frequency.

Static data requires human manipulation to be useful: Many agencies face this when converting their timetable data to the GTFS standard. Real time data may be easier, as the process could have automatic manipulation.

Similarly, the naming of routes sometimes differs internally and externally: Many agencies have intricate naming systems for their routes, which may not be the same as the published route numbers. This can lead to complications when developing interfaces between internal and external systems.

Time lag in releasing real-time data: Some agencies are wary about releasing real-time data due to time lag; however, vendors state their best interest is providing the most accurate data as possible (i.e. the market works).

Multiple GPS devices on a single bus create complexity: A bus can have many different GPS systems because of the different systems and the times that these systems are installed. Some agencies express that this isn't a major challenge and, in fact, provides a back-up in the event there is a GPS failure; however, maintaining duplicative systems is not cost effective.

Legal

Those who fund grants do not necessarily know technical details: Often the RFP is designed by grant requirements and not based on what the agencies need. For example, some vendors specify that they own the database but the agency owns the data, leading to complications if an agency seeks to make their data available publicly.

Agencies perceive smaller vendors as less reliable than larger vendors: Agencies are hesitant to use smaller vendors as they are perceived as less reliable, therefore they may lock themselves into more restrictive contracts. An open architecture could help solve this problem.

Agencies are starting to recognize problems with proprietary systems: Ownership and storage of data that agencies may want to share publicly may present problems if the data collection and storage occurs on proprietary systems.

Agencies will need to be prepared to deal with a proliferation of third-party signage: Proliferation of real-time information by transit agencies allows developers and vendors to create their own signage, and accuracy and time lag can pose problems to customers expecting the most up-to-date information. At the Embarcadero station, a local coffee vendor has placed a real-time train arrival sign in the station that is not sanctioned by BART.

User Needs

Guidance on data standards: MTC is proposing standards for the region but would like to see some federal guidance. While *Google* presses ahead with its transit application and GTFS, agencies recognize that *Google* is a private business and cannot set all the standards. Many in the private sector feel that the federal government should not try and impose standards because *General Transit Feed Specification* is already in wide use.

Agencies should be encouraged to release data: Third party developers can quickly create advanced wayfinding technologies and applications, getting them to market quickly.

Aid small and/or rural agencies to convert timetable data to GTFS: Caltrans and Virginia DOT have helped small and rural agencies to get their data into GTFS. More state DOTs could be encouraged to take a similar approach.

A checklist of what an agency should look for when considering technology solutions.

The State of the Future

Cell phones as traffic probes: Research includes the Networked Traveler program by Caltrans with the goal of using cell phones as traffic probes, relaying not only traffic information back to users but also alternative transportation information, allowing users to change routes or modes based on real time information. Real-time data may also allow transportation management centers to actively manage demand.

Headway-based operations: Another upcoming practice may be the movement away from schedule-based operations to headway-based operations. Real-time vehicle information at stops, online, and in users' hands (cell phones and PDAs) may negate the need for a schedule, freeing transit operators to run service more efficiently and effectively. The San Francisco MTA already discontinued the distribution of printed schedules, to little pushback from customers. With real-time information and a strong web-presence, SFMTA is able to begin realizing the savings of providing these systems. By operating on headways instead of schedules, an agency can better utilize signal priority systems without buses having to wait for a schedule adjustment.

Incorporating advanced wayfinding technology into static signage: Future transportation systems need to consider the integration of data and wayfinding technology, including static signage. Already the MTC is considering signage for new Transbay Terminal in San Francisco.

Mash-ups: The development of "mashups" will create unique and new applications. One of these is the use of the GraphServer open source trip planner to display a "transit shed" on the WalkScore website.

Multi-modal trip planners: Multi-modal trip planners will enable travelers to make better transportation decisions with more information than ever. With real-time transit and traffic data, travelers will be able to compare across modes the best way to reach their destination. These trip planners may also provide travelers with accurate estimations of not only travel time, but also monetary cost and information on carbon emissions.

The components and willingness to provide as much information to travelers as possible is in place, as is the willingness of the users to adopt technologies to utilize this information. At the agency level, with private sector vendors and developers, and at the MTC, movement is afoot to create real-time trip planners that allow travelers to compare travel times, cost and environmental impacts across modes. The MTC is working towards creating an application programming interface (API) for its trip planner so users can incorporate the 511 trip planner on their own websites.

Seattle

Purpose for visit

The Seattle Metropolitan Area is a region with a number of transit agencies and unique inter-agency partnerships. The University of Washington's Washington State Transportation Research Center (UW-TRAC) also has begun to play an important role in the public transportation traveler information realm.

Agencies, government organizations and developers in Seattle interviewed as part of this study were:

- King County Metro
- Sound Transit
- UW-TRAC: One Bus Away Developers
- Washington State Ferries

Technology Showcase

The following chart showcases the variety of technology in place at the various agencies.

Table 8: Seattle Area Technologies

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Trip Planner	King County Metro	Web-based trip planner with Trapeze data and schedule management. Integrated with Sound Transit routes, Pierce County, Snohomish County, and Washington State Ferries.
Bus Location Information	King County Metro	Uses out-dated signpost technology to track buses. Shows real-time location of buses, available to the public on the web. OTHER: New radio and CAD/AVL will improve

		vehicle location information (eliminating signpost bus tracking).
Predicted Bus Arrival Information	King County Metro/Sound Transit	One Bus Away: iPhone application. One Bus Away website currently matches the amount of traffic visiting the official King County Metro website.
Remote Infrared Audible Signage (RIAS)	Sound Transit	Pilot project completed – 500 signs in 6 stations. Results currently being reviewed by the Volpe Center.
Ferry Location Information	Washington State Ferries (WSDOT)	Using GPS, tracks ferries and displays real-time locations on the web.
Webcam Queue Monitoring	Washington State Ferries (WSDOT)	Displays webcams on the internet so passengers with vehicles can monitor length of queue.
<i>Google Transit</i>	All Agencies	All agencies provide data in GTFS to be used in <i>Google Transit</i> . GTFS is publicly available for use by independent developers.
Service Alert Blog	Sound Transit	Social media.
Email Service Alert	King County Metro/Sound Transit	Subscription service providing route-specific information.
Twitter	King County Metro/Sound Transit	Social media.

Background

King County Metro is the major transit provider in Seattle, with more than a thousand buses in its fleet. For years, KCM has made an effort to utilize wayfinding technology, deploying one of the earliest internet-based bus tracking systems available to the public. Its present-day systems have become antiquated, and KCM is in the process of developing a new “smart bus” system that will include a new radio system, new GPS-based CAD/AVL, on-board vehicle diagnostics, passenger counters, and more. The new hardware and software will be deployed on the RapidRide, a network of new rapid bus corridors throughout King County.

King County Metro is a strong leader in regional and multi-agency cooperation. Pierce County Transit (to the south) and Snohomish County Transit (to the north), are both integrated into KCM’s online trip planner, and Sound Transit was established as a regional transit agency to oversee commuter rail (the Sounder), light rail (the Link), and a number of cross-municipal bus

routes. The ORCA card (One Regional Card for All) is another successful product of this cooperation.

Finally, KCM has a strong working relationship with the Washington State Transportation Research Centers at both the University of Washington and Washington State University. A number of important wayfinding applications have been developed at the universities, and the Volpe Center felt that an interview with the developers of the successful “One Bus Away” program would inform the project in a unique way and provide different perspectives on wayfinding technology.

Real-Time Information

For years now, King County Metro has made an effort to utilize real-time data, deploying one of the earliest internet-based bus tracking systems available to the public. Today, KCM’s systems have become obsolete, and KCM is in the process of implementing a new “smart bus” system that will include a new radio system, new GPS-based CAD/AVL, on-board vehicle diagnostics, passenger counters, and more. The new hardware and software will initially be deployed on the RapidRide, a network of new rapid bus corridors throughout King County, before full integration into the entire system. Real-time tracking and time-of-arrival information is also available for the new Link light rail.

Washington State Ferries has a different set of issues than most transit agencies, and while many of its information processes are outdated, they still manage to provide useful real-time data to its riders. One major issue is the very long queue of cars that wait for the ferry’s arrival. In order to provide a real-time status to its riders, the agency posts live video on its website and allows viewers to determine whether there is still room on the next boat.

Trip Planner

KCM has a strong working relationship with the Washington State Transportation Research Centers at both the University of Washington and Washington State University. The “One Bus Away” real-time trip planning application has been recognized as a successful tool for riders in the Seattle area and in many ways is now the city’s de facto trip planner. The “One Bus Away” website visitor count is equivalent to that of King County Metro’s own trip planner.

Many of the problems with Seattle’s wayfinding and traveler information technology were exposed during the winter of 2009, in which the region experienced three unprecedented snow storms in a row, leaving much of the city crippled. Buses had to abandon routes, and schedules were in disarray, but there was no way of providing the full level of detail to commuters. Much of this stemmed from KCM’s old bus tracking system, which involves fixed polling stations situated approximately five minutes apart from each other. Though it works when a bus is on-route as expected, the fixed-poll system is unable to track buses that are pushed off-route. Not surprisingly, these types of situations occur during times of emergency, a critical time for a

transportation system to work as effectively as possible. Metro received abundant criticism for its handling of the 2009 storms and was focused since then on improving general and emergency wayfinding information in the coming years.

Data Sharing

King County Metro has shown strong leadership with regard to regional and multi-agency cooperation. Pierce Transit and Snohomish Transit are both integrated into KCM's online trip planner, and Sound Transit was established as a regional transit provider to oversee Sounder, the Link, and a number of regional bus routes. Deployment of the ORCA card (One Regional Card for All) is one of the major successes of this cooperation.

KCM has long believed in providing bus tracking information to the public, and as *Google's* transit feed specification came into being, KCM was one of the first major agencies to cooperate. With the data publicly available, KCM began to benefit from one of the country's most robust network of transit application developers.

Washington State Ferries plays a unique role with regard to regional data sharing. As the largest passenger and automobile ferry system in the United States, the Washington State Ferries relies heavily on connections with other regional transit services. Because ferries generally have a very large capacity and sail at intervals far less frequent than a typical transit headway, operators are able to adjust departure times in order to accommodate delays in other transit modes. Consequently, it is important for Washington State Ferries to communicate effectively and share as much data as possible with KCM, Sound Transit, other transit agencies in the region, as well as the public. The FTA funded a Research and Development project to demonstrate higher rates of "wireless-over-water" data transmission on the ferries in 2007 and 2008.

Challenges

Incorporating third-party vendor software into agency programs: Local transit agencies want to ensure that if a third-party trip application becomes the primary trip planner for greater Seattle, information provided by the service is up-to-date and accurate.

Implementing new technologies : King County Metro reports that in many ways they have been "held hostage" by existing proprietary operating systems, meaning that incremental changes or improvements in software or hardware are often restricted by the systems that are already in place. KCM has begun a complete overhaul with its "SmartBus" program, but there are still concerns that the agency will again be committing to years of maintenance and improvement of the chosen hardware and software packages.

Labor Issues: Typically, distinct unions represent workers based on specific skills associated with a particular on-board system (electronics, mechanics, radio, etc). The new SmartBus

program integrates all systems into one, placing fewer demands on specialized workers and creating a need for a different kind of skilled labor.

User Needs

Transit to open source software: KCM would like to pursue open source software, but needs extensive help with the transition. They would like to see a federal focus on the transition to open sources in general, rather than the software itself.

The State of the Future

Location-based services around transit stops: The University of Washington would like offer location-based services around bus stops in their technology offerings.

Houston, Dallas, and Austin, Texas

Purpose for visit

Texas has some of the nation's fastest growing urban areas, and three major metropolitan areas, Houston, Dallas, and Austin, have recently made significant investments in public transportation. Each metropolitan area is unique. For example, Houston's land use patterns and influx of new residents following Hurricane Katrina presents different challenges than Dallas, where multiple urban cores (Dallas and Fort Worth), and separate agencies offer differing services. The capital city, Austin, is a hot-bed of technology development, home to Dell Computers and the University of Texas. All three are growing rapidly, and are extending their transit services and attracting new riders (and keeping them) is important.

Agencies, government organizations and developers in Texas interviewed as part of this study were:

- Capital Metro (Austin)
- City of Austin Department of Transportation
- Dadnab (software developer)
- Dallas Area Rapid Transit (DART)
- Fd2s (design firm)
- Houston Metro
- Texas Department of Transportation (TxDOT)

Technology Showcase

The following chart showcases the variety of technology in place at the various agencies.

Table 9: Texas Technologies

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Quickline	Houston Metro	New BRT-like service has significant marketing scheme attached as well as pavement striping indicating the route.
iPod route maps	Houston Metro	Bus route maps are available for download in an iPod compatible format.
Where's My Bus?	Dallas Area Rapid Transit (DART)	Mobile and web-based application for real-time bus arrival information.
Innovative wayfinding study	Capital Metro (Metro)	CapMetro contract with Fd2s to study how users interact with the transit system. Study followed.
MyCapMetro	Capital Metro (Metro)	Developing a user-customizable website that stores common trips, next bus arrival information for selected routes, etc.
Houston Cancer Center Trip Planner	Fd2s	A kiosk-based trip planning system combined with a new wayfinding system was developed by Fd2s for a major hospital in Houston. The system allows visitors unfamiliar with the labyrinthine hospital to enter pertinent information, such as appointment data, and will print out a unique trip plan based on the current location using new wayfinding measures, such as renamed hallways and elevator banks. This could be applied in large transportation hubs such as airports and train stations.
SMS Text Message trip planner	Dadnab	Trip planner available to cell phone users through SMS text message. Underlying software "scrapes" transit trip planner and sends trip data back to user.

Background

Houston Metro has recently unveiled the Quickline, a rapid bus corridor that connects directly to their downtown light rail. Houston places an emphasis not just on improving its traveler information services, but also on tracking data to provide accurate assessments of its recently deployed programs.

Dallas is taking the lead from more transit-friendly regions, such as Portland and San Francisco, and is embracing open source opportunities. Dallas Area Rapid Transit (DART) continues to develop one of the nation's most extensive light rail systems.

Austin's CapMetro will soon begin commuter rail service, the first new passenger rail project in the capital city region in decades. While there are overlaps in the agencies' approaches to wayfinding and traveler information technology, there are also variations that the Volpe Center hoped to explore. Austin has invested significantly in more traditional wayfinding practices, sponsoring a number of professional studies that capture rider behavior and the psychology of wayfinding.

Real-Time Information

With the introduction of Quickline, Houston Metro is providing real-time vehicle departure information on signs at stops along the route. The system uses the same AVL/CAD system as other routes; however, the polling rate is every 30 seconds versus three minutes for other routes. Houston Metro cites the old radio network as being incapable of handling a more widespread roll-out of real-time information as it is unable to transmit more frequent poll rates.

In Dallas, DART has had internal real-time bus location information since 1992; however, they only recently developed their Where's My Bus mobile application. Where's My Bus allows users to select their route, direction of travel and bus stop and returns a prediction of the next arriving bus. When conceiving the project, DART's efforts were delayed by legal questions by intellectual property questions. As a result, DART paid a \$100,000 licensing fee to ArrivalStar.

Trip Planner

DART maintains their own trip planner while simultaneously offering *Google Transit* on their website. Following the introduction of *Google Transit*, use of DART's own planner declined. Sometimes, the two trip planners give customers different itineraries for the same trip.

In Austin, Capital Metro and Dadnab have a unique relationship. Dadnab's cell phone trip planning tool allows users to text in an intersection to return the next trip according to schedule data. Dadnab's service "scrapes" Capital Metro's web-based trip planner to determine itineraries. While no formal agreement exists between Capital Metro and Dadnab, Capital Metro and Dadnab communicate on such things as changes to the web site code so that Dadnab service remains consistent. Capital Metro also includes Dadnab information on its information signs at some bus stops. Dadnab is available in other cities as well, including San Francisco, Boston and Chicago, among others.

Capital Metro, which also uses *Google Transit* and provides their data in GTFS format, participates in the *Google Transit* forum. The forum allows agencies and users to exchange ideas on everything from converting timetable data to GTFS to the creation of tools for the service.

Fd2s, a wayfinding consulting and environmental graphic firm in Austin, not only completed a traditional wayfinding study for Capital Metro, they implemented an innovative kiosk-based trip planner at the Texas Medical Center (TMC) in Houston. At TMC, patients and visitors can enter their appointment or location onto a touch screen kiosk, which then prints out directions to the location from the kiosk's location. One requirement necessary to implement the system was renaming some hallways and elevator banks to facilitate easier navigation. This type of system may present opportunities for complex transit hubs such as trains stations and airports.

Challenges

Institutional

Ridership Demographics: According to the agencies, there are fewer “choice” transit riders in the major Texas cities. While there are a growing number of residents who can drive but choose to ride transit, it is still largely comprised of riders who do not have access to a private car.

Implementing 5-1-1: DART would like to foster a regional partnership among transit agencies to provide transportation information to travelers. The state DOT is considering 5-1-1 implementation, and DART is awaiting action at the state level.

Technological

Inadequate bandwidth: In Houston, an antiquated radio system prevents Houston Metro from polling their buses any faster than every three minutes, although they do poll buses on the Quickline every 90 seconds.

Too much data: DART has more information than they are able to distribute to the public. If they can get a more intelligent network, they do not have to worry too much about the end user, as third party developers and vendors can take the lead in manipulating the data into useable formats.

Conversion of data to GTFS: DART wants to develop a regional trip planner; however, some agencies lack the necessary resources, such as staff to convert timetables into GTFS format.

Legal

Patent Issues: In developing its *WheresMyBus* mobile application, DART's legal team paid a significant amount for the rights to a patent held by ArrivalStar. (Link to patents held by ArrivalStar: <http://www.patentgenius.com/assignee/ArrivalStarInc.html>.)

Terminology: DART was not allowed to use the name “Next Bus” for their real time prediction service, naming it “Where’s My Bus” instead.

User Needs

Demonstrate benefits—agencies need help in identifying ways to show advanced wayfinding technology benefits to the public.

Content standards: standards for signage similar to interstate and U.S. highway signs could be created. The standards do not have to be precise, but could include guidelines on size of text, contrast, and information.

Washington, D.C. Metropolitan Area

Purpose for visit

The Washington, D.C. Metropolitan Area consists of two states, Maryland and Virginia, and the District of Columbia and includes 5.4 million people. The area's public transportation system is the fourth largest in North America, and provides roughly 486 million trips per year. The largest transit operator in the area, Washington Metropolitan Area Transit Authority (WMATA), operates Metrorail and Metrobus service, while 14 other transit agencies operate bus service and two operate commuter rail systems. The following agencies were interviewed as part of the study:

- Alexandria Transit (DASH)
- Arlington Transit (ART)
- Fairfax CUE Bus
- Metropolitan Washington Council of Governments (MWCOG)
- Virginia Department of Rail and Public Transit (DRPT)
- Virginia Department of Transportation (VDOT)
- Virginia Railway Express (VRE)
- Washington Metropolitan Area Transit Authority (WMATA)

Technology Showcase

The following chart showcases the variety of technology in place at the various agencies and through private third-party vendors.

Table 10: Washington, D.C. Metropolitan Area Technologies

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Regional Trip Planner	WMATA	Ride Guide: WMATA is responsible for the regional transit trip planner. It is currently a static trip planner (it does not update results based on real-time vehicle positions), and WMATA solicits updated schedules and routes from regional transit agencies periodically.

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
Real-time Bus Arrival Information	CUE	NextBus: Cue has used NextBus since roughly 2000. GPS units are installed on 12 buses, 8 of which are used on weekdays and 4 on weekends. There are 6 LED signs at 6 bus shelters including the Vienna Metrorail station. Customers may retrieve next arrival times via drop down menus on the web or via a system maps that refreshes every thirty seconds. The arrival times are within 1 to 2 minute accuracy.
	WMATA	NextBus: WMATA began its second attempt at NextBus service in July 2009. The previous attempt failed when over 80% of its predicted arrival times were inaccurate. The more recent attempt has been more successful. To use it, riders call a 1-800 number, type in a bus stop identification number, and an automated system informs the rider of the predicted arrival times.
	ART	Connexionz GPS System: Connexions operate by way of digital signs at ART bus stops. To obtain the next arrival time, the rider places his or her finger on a sensor on the digital display. Once the sensor is activated, the estimated arrival time appears on the digital display.
E-mail service alerts	WMATA	eAlerts: WMATA emails out three types of service alerts for the Metrorail system. Metrorail eAlerts provide notices of disruptions in rail service. Metrorail eAlerts may be customized by line, time of day, or day of week. MetroAccess eAlerts provide notice of service disruptions due to weather or other emergencies. Elevator eAlerts provide notice of elevator outages.
Vehicle Location Map	WMATA	NextBus: WMATA's NextBus system includes static and dynamic maps on the NextBus webpage.
	WMATA	WMATA provides a cell phone application that enables the user to identify the next vehicle arriving at the stop or station.
	CUE	NextBus: WMATA's NextBus system includes static and dynamic maps on the NextBus webpage.
	VRE	RailTime: VRE's RailTime system shows approximate real-time location of trains, available to the public on the web. Trains are represented in one of three states: "On-Time," "Delayed," or "Lost Communications."

PROJECT	SPONSOR	TECHNOLOGY INFORMATION
	DASH	DASH is in the process of implementing a real-time location and arrival prediction system and expects to provide a real-time online map to users when it is complete.
Twitter	VRE	VaRailXpress: VRE is using Twitter to communicate service disruptions to its riders. Riders may sign up to follow VRE “tweets” on the VRE website.
<i>Google Transit</i> Trip Planner	DRPT	Statewide effort by Virginia Department of Rail and Public Transportation to help transit agencies to provide route and timetable information to <i>Google Transit</i> in the <i>General Transit Feed Specification</i> (GTFS) format.
Traveler Information Center	WMATA	Customer Information: The WMATA call center remains an important source of information for tourists or infrequent users. For example, call volume increased five times prior to the 2009 presidential inauguration. Despite WMATA’s commitment to the service, there has been a reduction in authorized staffing for the call center as use of mobile technology has become more prevalent.
Transit television	WMATA	METRO Channel: WMATA is developing its “METRO Channel” which will be streamed on LCD televisions on platforms, mezzanines, station entrances, and eventually, rolling-stock. The screens will provide information regarding outages, time, station information, connecting services, news, weather, and advertising. The new screens are expected to increase the bandwidth for customer information 100x over the current LED displays in the Metrorail stations.
Data warehouse	University of Maryland CATLAB	Regional Integrated Transportation Information System (RITIS): Built and maintained by University of Maryland's Center for Advanced Transportation Technology Laboratory (CATT Lab). RITIS integrates existing transit and transportation management data in Virginia, Maryland, and Washington, D.C. RITIS automatically fuses, translates, and standardizes data obtained from multiple agencies in the region, in order to provide an enhanced overall view of the region’s transportation network.

Background

Real-Time Information

Provision of real-time location information to riders is becoming more commonplace in the Washington, D.C. Metropolitan Area. Fairfax's CUE system was an early adopter when it installed NextBus technology on its buses in 2000. CUE had a few early issues with its system: the GPS transmitters interfered with the low-band communications radio of the buses and prompted CUE to switch to high-band communications radios. Also, the NextBus dynamic message signs occasionally lose the cellular service they use to obtain updated arrival times.

WMATA attempted a NextBus implementation in Fall 2007 but achieved prediction accuracy of less than 80%. It was discontinued indefinitely as the agency worked with NextBus to improve the results. In spring of 2009 riders found an internal testing site for the service, which was promptly closed to public access until testing could be completed. WMATA re-released an improved NextBus system in July 2009.

Arlington's ART has its *Connexionz* system which will provide an estimated arrival time on a sign at select bus stops when the rider covers a sensor with their finger.

DASH is currently working to implement a real-time location and arrival estimation system. DASH obtained some experience with such a system during a previous pilot program, and this time the agency is focusing its testing efforts on its most difficult route, one that serves the Pentagon. DASH suggests that if it can get its most challenging route operational, the remaining routes should be relatively easy.

Trip Planners

Numerous trip planners exist among the region's transit agencies. With the help of DRPT, over thirty small transit agencies provide their schedule information to *Google Transit*. Of those agencies interviewed, DASH and CUE provide data to *Google Transit*. DASH uses *Google Transit* to provide its own trip planner and also participates in the regional trip planner maintained by WMATA. WMATA has released its data in the *General Transit Feed Specification* (GTFS) but does not have a terms and conditions agreement with *Google*. Thus, WMATA's route and timetable information is not part of *Google Transit*. Several other smaller transit agencies near Washington, D.C., such as ART, have followed WMATA's lead.

Data-Sharing

While many agencies share static information with the public and third-party developers, agencies are not yet sharing real-time data with the public or third party developers. A representative from a small transit agency commented that the agency was unsure how WMATA obtains its static data for the regional trip planner and said that the smaller agency does not provide updates to WMATA when the smaller agency changes schedule.

RITIS has become a de facto information repository for traffic information in the region, although it is currently more focused on roads and highways than transit systems. Several individuals interviewed suggested that if a real-time trip planner were developed, RITIS may play a role in the data collection and fusion of the data. This may be a significant challenge, because most of the transit systems with real-time location data have different vendors and data formats.

Challenges

Institutional

Communicating with the public - managing expectations: WMATA experienced public backlash regarding both its decision to end public access to its NextBus testing website before re-launching service in 2009 and its decision not to work with *Google Transit*, but to eventually release data publicly in the GTFS.

Accuracy versus speed: For VRE, the biggest challenge with real-time information is when and what messages to communicate. Regular customers, often upper-middle class and technology savvy commuters, are most interested in updates regarding service disruptions and expect electronic communications regarding service delays in a timely manner. VRE's challenge is to balance accuracy of a message with timeliness – sometimes the agency must make educated guesses not only about what is wrong, but about when service will resume. VRE sometimes feels like it is a race with the media and riders. Sometimes riders will inform the media of service disruptions via SMS, Twitter, or other mobile technologies before VRE, and VRE would prefer to be the source of service disruption information. Furthermore, because riders can use their mobile devices to obtain updates from the media, VRE train crews tend to get frustrated when passengers have more information regarding service disruptions than they do.

Google Transit participation: Smaller agencies have been more willing to participate with *Google Transit* – Larger agencies are more likely than smaller agencies to have legal and business concerns with *Google Transit* and are slower or resistant to partnering. Smaller agencies are more immediately concerned with increasing their ridership and see *Google Transit* as a virtually free tool to do so. Though DRPT extended the opportunity for all Virginia transit agencies to take part in a concerted effort to participate with *Google*, participation was higher for those agencies outside of the Washington, D.C. Metropolitan Area. Some interviewees suggested that many of the agencies in the metropolitan area were following WMATA's lead on whether or not to participate.

Marketing trends of available trip planning and wayfinding tools vary by agency: Many of the transit agencies that are participating with *Google Transit* are not advertising it on their websites. A major marketing campaign by DRPT was suspended following a change in the department's leadership.

Communication among agencies is complex: The number of transit systems, planning and policy bodies, and governments in what is essentially a three-state governing area, are large and complex. WMATA is the largest and carries a great deal of weight regarding systems, standards, and policies.

Technological

Google Transit accuracy and connectivity: Several agencies not participating with *Google Transit* suggested a main reason for not participating was that not all connecting agencies were participating, and that interagency connections would be represented. VRE attempted to participate with *Google Transit* but found the tool did not properly route travelers to the train stations.

GPS accuracy: DASH is currently testing a real-time location and arrival prediction system on its most complicated route which serves the Pentagon. The Pentagon presents several technological challenges. First, DASH may stop at different bays at the station; thus, it is difficult relay that a bus has “arrived.” Second, the layover point for the route is located very close to the station; thus, it is difficult to distinguish whether the bus is out of service or at the bus stop. DASH expects that if it can resolve these difficult challenges, it can more easily resolve less difficult challenges on its other routes.

Differences in technology: In general there are numerous technology differences among agencies in the Washington, D.C. Metropolitan Area. Difference in vendors, technologies, and data formats is expected to be a significant technical challenge if and when the region begins working on a multi-agency real-time trip planner.

Multiple GPS antennae: Due to technical limitations, piecemeal funding, and issues related to vendor interoperability, several bus systems have multiple GPS antennae that each fulfill a different function.

Integrity of core systems: WMATA noted a primary challenge is the data integrity of the core systems that operate train and buses and produce customer information. Examples include the rail control system and the maintenance inventory database. Customer information systems cannot be based on inaccurate or non-normalized data.

Selection of ITS systems: Although WMATA would like to use more open source solutions, it typically seeks solutions that are widely used and well documented, “commercially available off-the-shelf” (COTS) systems. WMATA prefers products with well documented APIs; however, the agency notes that not all vendors make these available. Furthermore, WMATA notes that some software installations require changes in business processes, yet these processes are organizationally difficult to update.

Radio interference: When first installed, the GPS units on the CUE bus system interfered with the low-band radio system, thus prompting an upgrade of the radios to high-band.

Equipment consistency: Especially for big transit systems, technology improvements are difficult to make all at once due to limited funding. If significant time occurs between implementation, technology and equipment can change, resulting in a complex variety of bus equipment configurations that are difficult to manage.

Legal

Procurement: One Virginia transit agency was not able to immediately participate with *Google Transit* due to its procurement process. Even though *Google* would not be receiving payment for service, the agency would have had to put forth an RFP and conduct a competitive selection process.

Terms of service: WMATA took issue with the terms of service for *Google Transit* but declined to elaborate on the exact issue. Instead of participating directly, WMATA released its route and schedule information in the GTFS with its own terms of service that third party developers must agree to prior to using the data. At the time of writing WMATA route and timetable information has not been incorporated into *Google Transit*.

Lessons Learned

Ensure high quality of information before releasing services to the public: WMATA, having learned from its initial NextBus implementation, has focused on quality of information prior to re-releasing NextBus in July 2009. Other systems interviewed suggested the same lesson and noted they focus on testing to ensure successful delivery to the public.

Communicate transparently with the public regarding implementation schedule and plans: WMATA received a great deal of backlash removing public access to its NextBus testing website and for resisting to release its routing and scheduling information publically. In the case of the former, the agency may have avoided public outcry if it had been transparent regarding the implementation schedule and the testing process and if it had been more careful to protect the testing website from public view. In the case of the latter, WMATA was inconsistent for a period of weeks regarding availability of and access to route and schedule information. Although WMATA has released its route and timetable in the GTFS format, it has not revealed its specific issues with *Google Transit's* terms of service.

Take advantage of economies of scale: DRPT's approach to working with *Google* was unique. It created a master contract between itself and *Google* (a public and private entity) and then created individual agreements (public to public) with participating transit agencies (grantees). The grantee agreements were not specific to working with *Google*, thus the schedule and route information may be shared with anyone that asks for it. The contract with *Google* took two

months to negotiate. DRPT conducted several outreach meetings with grantees and *Google* to discuss the product, the process, and any of the grantees' concerns. The agency hired a consultant for \$30,000 to train and assist grantees with formatting their routes and schedules in the *General Transit Feed Specification*. Some agencies needed no help at all, some needed a lot of help, and most others were somewhere in between. Some agencies already had software that could output in *General Transit Feed Specification*. Once data was sent by grantees to *Google*, *Google* created preview websites which the grantees could test, make changes as necessary, and then release to the public.

User Needs

Guidance related to *Google Transit*, including the technological, policy-oriented, and legal pros and cons of *Google Transit* and provide guidance to both small and large agencies regarding participation.

Support for ITS use by small and rural providers. This could include a national discussion forum, leadership, and outreach with small, rural providers who may feel disconnected or left out of ITS-related discussions.

Guidance to help agencies make informed vendor and technology choices, such as documentation of software and hardware configurations.

Washington area agencies noted that, for some wayfinding equipment and transit vehicles, European suppliers have highly desirable technology, but they are prohibited from purchasing these items due to the Buy America regulations. They would like to see federal intervention to change these provisions and facilitate the purchase of products that encourage transit use, such as wayfinding equipment.

Assistance in fostering open standards among vendors and transit providers. Some agencies would like to see an open-source "ecosystem" in which to create technology applications, including standards for open source data. Transit technology incubators, especially those that develop open architectures, were also desired.

Appendix C: List of Agencies and Entities Interviewed

Table 11: Wayfinding Technology Assessment - Agencies and Entities Interviewed

AGENCY NAME	LOCATION	AGENCY TYPE
Alameda Contra Costa Transit District	Oakland, California	Public
Alexandria Transit - DASH	Alexandria, Virginia	Public
Arlington Transit	Arlington, Virginia	Public
Bay Area Rapid Transit District	Oakland, California	Public
California Department of Transportation	Sacramento, California	Public
Capital Metropolitan Transportation Authority	Austin, Texas	Public
Centre Area Transportation Authority	State College, Pennsylvania	Public
Champaign-Urbana Mass Transit District	Urbana, Illinois	Public
Chicago Regional Transit Authority	Chicago, Illinois	Public
Chicago Transit Authority	Chicago, Illinois	Public
City of Austin Department of Transportation	Austin, Texas	Public
City of Chicago, Office of Emergency Management and Communications	Chicago, Illinois	Public
Dallas Area Rapid Transit	Dallas, Texas	Public
Duluth Transit Authority	Duluth, Minnesota	Public
Fairfax CUE Bus System	Fairfax, Virginia	Public
Federal Highway Administration Metro Division	New York, New York	Public
GoTriangle	Raleigh-Durham-Chapel Hill, North Carolina	Public
Metropolitan Transit Authority of Harris County	Houston, Texas	Public
Illinois Department of Transportation	Springfield, Illinois	Public
King County Metro	Seattle, Washington	Public
Lane Transit District	Eugene, Oregon	Public
Madison Metro Transit	Madison, Wisconsin	Public
Massachusetts Bay Transportation Authority	Boston, Massachusetts	Public
Metro Transit	Minneapolis, Minnesota	Public
Metropolitan Transportation Commission	Oakland, California	Public
Metropolitan Washington Council of Governments	Washington, District of Columbia	Public
Milwaukee County Transit System	Milwaukee, Wisconsin	Public
MTA New York City Transit	New York, New York	Public
New York Metropolitan Transportation Authority	New York, New York	Public

AGENCY NAME	LOCATION	AGENCY TYPE
Oregon Department of Transportation	Portland, Oregon	Public
Oregon Metro	Portland, Oregon	Public
Pace Suburban Bus Service	Arlington Heights, Illinois	Public
Port Authority of Allegheny County	Pittsburgh, Pennsylvania	Public
Port Authority Trans-Hudson Corporation	Jersey City, New Jersey	Public
Portland Streetcar	Portland, Oregon	Public
Metropolitan Transportation Commission	Oakland, California	Public
San Mateo County Transit District	San Mateo, California	Public
Sound Transit – Central Puget Sound Regional Transportation Authority	Seattle, Washington	Public
Texas Department of Transportation	Austin, Texas	Public
The Open Planning Project	New York, New York	Public
TRANSCOM	Jersey City, New Jersey	Public
TriMet – Tri-County Metropolitan Transportation District of Oregon	Portland, Oregon	Public
University of California Partners for Advanced Transit and Highways	Berkeley, California	Public
Santa Clara Valley Transportation Authority	San Jose, California	Public
Virginia Department of Rail and Public Transit	Richmond, Virginia	Public
Virginia Department of Transportation	Richmond, Virginia	Public
Virginia Railway Express	Alexandria, Virginia	Public
Washington Metropolitan Area Transit Authority	Washington, District of Columbia	Public
Washington State Ferries	Seattle, Washington	Public
Avego	Kinsale, Ireland	Private
Continental-Siemens	International	Private
Dadnab	Austin, Texas	Private
Fd2s	Austin, Texas	Private
Google, Inc.	Mountain View, California	Private
NextBus, Inc.	Alameda, California	Private
Pandav, Inc.	San Francisco, California	Private
RouteShout	Pittsburgh, Pennsylvania	Private
Trillium Insight	Portland, Oregon	Private
Center for Urban Transportation Research, University of South Florida	Tampa, Florida	Academic
Harvard University	Boston, Massachusetts	Academic
Portland State University, Oregon	Portland, Oregon	Academic

AGENCY NAME	LOCATION	AGENCY TYPE
Transportation Research and Education Consortium		
University of Washington, State Transportation Research Center	Seattle, Washington	Academic

Appendix D. Proposed Projects in the FTA ITS Research Plan – 2010-2014

Projects linked to transit wayfinding/traveler information technologies

Full descriptions of the 15 relevant ITS architecture, ITS standards or systems engineering projects proposed in the *FTA's ITS Research Plan – 2010-2014* are presented in this Appendix. Each project lists title, purpose, approach, deliverables/outcomes, program goal, research phase, and project fiscal year(s).

1. Inform Transit Investments Decisions in Open Architecture versus Open Source versus Open Data Approaches to Developing ITS systems

Purpose: To assess the efficiencies, challenges, benefits, risks, and limitations to different “open” approaches and determine which results in the greater cost-effectiveness, less risk, and increased operational benefits.

Approach: As the business, personal consumer electronics, and applications industries move toward new platforms that support a more highly mobile society, transit agencies have been exploring opportunities and different approaches to building and operating their systems for more openness, transparency, and accessibility. This project is a baseline assessment and comparative study of three different (but not mutually exclusive) approaches to “open” systems to understand how each approach affects the transit agency's business models, business operations, customer service, costs, interoperability, system architecture, telecommunications, and other factors. Within the study, the FTA will: (1) work to determine what characteristics are important to transit agencies when implementing new systems for data sharing (e.g., free, easy-to- implement, widespread, secure, widely used, allow for collaborative information exchange); (2) determine what approach to system implementation is most beneficial to transit authorities (allows flexibility but also provides structures for business operations); (3) assess future industry trends for exchange and accessibility (coordinate this with projects in Goal areas 5 and 6); and (4) analyze and compare costs, risks, timely deliver, extendibility of system, vulnerabilities, system security, and benefits of the approaches. This research will be conducted in cooperation with industry to validate which approach (or both) merit industry use. The research will be conducted in three parts:

- (1) **Baseline Assessment:** In FY10, the FTA will conduct an analysis which will be based on engaging up to two agencies who are willing to open their doors, provide details, and help develop the report (with the use of a contractor to pull together);
- (2) **Development:** In mid-FY11, based on the results, the FTA will conduct modeling of one or more of the systems to understand implementation issues, best practices, and system concepts; and

- (3) **Cross-Cutting:** Based on those results, the FTA expects to conduct knowledge transfer in FY2012.

Note: This research will build from and incorporate the existing FTA research on the White House's open data project and the *Google Transit* Format Standard (GTFS) that have been conducted by Noblis, as well as the TCIP benefits project listed above.

Deliverables/Outcomes: Agencies will be better informed on which approach offers the most appropriate investment through a report that will provide a comparative analysis and technical guidance on implementation. Vendors will be able to identify issues that need to be resolved with each approach in order to modify products and strategies.

Program Goal: Connected and Integrated Systems

Research Phase: Baseline Assessment

Project Fiscal Year(s): 2010

2. Inform Transit Investments Decisions in Open Architecture versus Open Source versus Open Data Approaches to Developing ITS systems

Purpose: To assess the efficiencies, challenges, benefits, risks, and limitations to different “open” approaches and determine which results in the greater cost-effectiveness, less risk, and increased operational benefits.

Approach: Based on the results of the FY2010 assessment, the FTA will conduct modeling of one or more of the systems to understand implementation issues, best practices, and system concepts.

Deliverables/Outcomes: Models that demonstrate the benefits and issues associated with “open” approaches to transit systems.

Program Goal: Connected and Integrated Systems

Research Phase: Development

Project Fiscal Year(s): 2011

3. Inform Transit Investments Decisions in Open Architecture versus Open Source versus Open Data Approaches to Developing ITS systems

Purpose: To assess the efficiencies, challenges, benefits, risks, and limitations to different “open” approaches and determine which results in the greater cost-effectiveness, less risk, and increased operational benefits.

Approach: The FTA expects to conduct knowledge transfer to the industry in FY2012 to present the results of the baseline assessment and modeling.

Deliverables/Outcomes: Model platform and specifications will be produced from this project, as well as the development of test results. In addition, transit industry awareness and training effort will be an outcome of this project.

Program Goal: Connected and Integrated Systems

Research Phase: Cross-Cutting

Project Fiscal Year(s): 2012

4. Integrated Corridor Management (ICM) Testing and Demonstration

Purpose: To demonstrate and test transit management capabilities within an Integrated Corridor.

Approach: FTA is involved as a working partner in demonstrating transit's role in the ICM initiative. This work will continue as an oversight role with the award to the ICM pilot sites to implement, test, and evaluate. Once results are available, FTA will work to demonstrate the opportunities and benefits to other transit agencies. An example demonstration project may be the collection of real-time capacity information in order to inform real-time operational decisions or determining the capacity of parking availability to support mode shift and increase transit usage. The demonstrations will be designed to establish proof-of-concept, identify best practices, and identify data gaps. The results will form the foundation for any further action plans.

Deliverables/Outcomes: Test and evaluation results.

Program Goal: Connected and Integrated Systems

Research Phase: Testing and Demonstration

Project Fiscal Year(s): 2010-2011

5. Assess Transit Cyber-Security Practices

Purpose: To assess and determine the frequency and seriousness of cyber attacks on transit agencies.

Approach: The FTA will conduct a study to determine system vulnerabilities with regard to system data, monitoring and sensor systems, security and firewall systems, authentication systems, electronic payment technologies, and others. With the Transportation Security

Agency (TSA) and FTA's Office of Safety and Security, the TRI staff will review methodologies and effectiveness of those practices that agencies currently use to protect themselves and their customers. A final report will document the range of internal/external data, closed/open information systems, and how they might be vulnerable. Additionally, the report will identify the data/information collection, analysis, distribution and storage technologies, systems, and best practices used by transit agencies for their security. The report is expected to be the foundation for TSA to develop training and guidelines for strengthening transit cyber-security. The effort will also include updates to FTA's Transit Security Guidebook, developed earlier in this century.

Deliverables/Outcomes: A report that provides recommendations and best practices for addressing cyber security for transit systems and for ensuring that agency data is more secure.

Program Goal: Safe and Secure Operating Environments

Research Phase: Baseline Assessment

Project Fiscal Year(s): 2010

6. Define and Assess "Real Time" Data for Transit Operations

Purpose: To develop an understanding of how "real-time" data will impact transit and transit ITS technologies and identify the potential for expanding into use of real-time data.

Approach: At the heart of future ITS solutions and the upcoming vehicle-to-vehicle and vehicle-to-infrastructure wireless applications are real-time data. Similar to the FHWA's work to define the characteristics for highway and arterial operations, the FTA will work with industry to define what "reliable" and "real-time" means for transit data. This work will:

- Determine what applications need "real-time" data and with what levels of frequency to optimize the system, and at what cost;
- Coordinate with the Integrated Corridor Management Initiative pilots to determine levels of quality and reliability, and to model impacts of real-time data on transit capacity;
- Look at the sources of the data (as part of the Real-Time Data Capture and Management initiative) and will determine how to use the available data (what transit data is available from vehicle-infrastructure connectivity, e.g., data from vehicle probes, and other real-time data sources.);
- Partner with industry to determine whether and how new applications would benefit from a transition to "real-time" data.

This work will be conducted as a multi-modal team effort with the ITS JPO, the FHWA, NHTSA, and the FMCSA. The FTA will ensure that the research covers bus, light rail, commuter rail, and heavy rail (subway) and will provide definitions and requirements for how transit vehicle use data or communicate data to the infrastructure differently than other vehicles and yet are still a

part of the road-user community that will exchange and use data in new and innovative ways going into the future. This work will also feed, in 2011, the definition of traffic/transit interface requirements that will look at how to better enable transit to receive data feeds on arterial data, the ability to share data with other agencies (both from a technical and institutional agreement standpoint), and the challenges and opportunities for interfaces when using open data formats.

Deliverables/Outcomes: Transit requirements for real-time data. This project will result in technology requirements for implementing real-time data. In addition, analysis of potential benefits, costs, and impacts to transit services will be produced.

Program Goal: Effective and Efficient Operations

Research Phase: Baseline Assessment

Project Fiscal Year(s): 2010

7. Develop Integrated Interfaces between Transit and Traffic Management

Purpose: To improve multi-modal coordination through shared data and decision support systems.

Approach: Building from the report assessing the real-time data needs for transit, the FTA will determine the function and impact of transit data within traffic management operations and vice-versa, determine what data requires more consistency, determine what links and requirements need to be implemented to enable interfaces, and develop the interfaces with the ITS JPO and the FHWA. The FTA intends to engage agencies and vendors through a competitive award with matching funds requirements to assist in development opportunities.

Deliverables/Outcomes: Data sharing interfaces and applications.

Program Goal: Effective and Efficient Operations

Research Phase: Development

Project Fiscal Year(s): 2011-2012

8. Test and Demonstrate Integrated Interfaces between Transit and Traffic Management

Purpose: To improve multi-modal coordination through shared data and decision support systems.

Approach: Using the research and prototype development in FY2011-2012, the FTA will work with agencies to pilot new interfaces within a test bed – potentially use the Integrated Corridor

Management pilot sites, the new FTA technology transfer test beds, or the connected vehicle test beds. The FTA intends to partner with both a traffic agency and a transit agency to implement within operations centers. Work will include the development of a test and evaluation methodology; evaluation; capturing of results and development of guidance on lessons learned and best practices.

Deliverables/Outcomes: Tested interfaces that can be transferred to the marketplace. This project will also result in guidance to agencies on implementation.

Program Goal: Effective and Efficient Operations

Research Phase: Testing and Demonstration

Project Fiscal Year(s): 2013-2014

9. Identify Transit Spectrum Relicensing and Requirements

Purpose: To work with industry to research and analyze the requirements and a transition path to relicensing the spectrum that is predominantly used for transit agency communications equipment.

Approach: The Federal Communications Commission (FCC) has notified the transit industry and the public about its intentions to split the bandwidth at 200Mghz, a frequency that supports many transit radio communications. The FTA is looking to take a facilitating role in exploring solutions to this issue that will include: (1) working with professional associations to create outreach to transit agencies to build awareness of the impending (2012) problem; (2) evaluate various other telecommunications approaches; explore whether nationwide procurement is an option or define procurement advice; and (3) analyze the impact based on existing shared-communications with emergency and first response providers, and guidance to the transit industry, among others. The outreach effort will continue through 2012, which is the transition date stated by the FCC within their rulemaking. An additional year has been added to this project (through 2013) to focus on those agencies who were not able to transition in time.

Deliverables/Outcomes: Policy recommendations and guidance.

Program Goal: Effective and Efficient Operations

Research Phase: Research and Analysis

Project Fiscal Year(s): 2010-2011

10. Guide Transit Spectrum Relicensing and Requirements

Purpose: To transfer knowledge to agencies on their requirements for relicensing

Approach: Based on the analysis in FY2010, the FTA will conduct outreach through 2012, which is the transition date stated by the FCC within their rulemaking. An additional year has been added to this project (through 2013) to focus on those agencies who were not able to transition in time.

Deliverables/Outcomes: Successful transit agency transition to new spectrum requirements.

Program Goal: Effective and Efficient Operations

Research Phase: Cross-Cutting

Project Fiscal Year(s): 2011-2013

11. Investigate Role and Impact of Social Media Applications on Transit Agencies

Purpose: To analyze how new social media applications are transforming transit agency operations, operational efficiencies and costs, and customer service.

Approach: The FTA will build on the previous research to understand how transit agencies are implementing social media and identify the impact that these new applications have on transit agencies. The results will feed three projects under Goal 6:

- Envisioning 21st Century Transit Agencies and Systems
- Investigating the Impacts of Social Media on Transit Users
- Developing New Operations and Revenue Models

Deliverables/Outcomes: Information for transit agencies to make the most efficient use of new social media applications.

Program Goal: Effective and Efficient Operations

Research Phase: Research and Analysis

Project Fiscal Year(s): 2010

12. Investigate the Impacts of Mobile Devices and Social Media on Transit

Purpose: To investigate social media applications and mobile devices, their impacts on transit, and future opportunities for their use in improving the transit rider's experience.

Approach: This project will build on previous and existing work to explore how Web 2.0 and new mobile technologies are changing the way travelers interact with transit services. The project will include research into the state-of-practice and explore what the future holds. This project will be closely coordinated with a similar project in Goal 3 that will investigate the

impact of social media on agency operations. This project will also help inform the research into livability applications.

Deliverables/Outcomes: A comprehensive list of Web 2.0 applications that are being used by the public or by transit agencies for transit traveler information. Best practices and information about deployments that peer agencies may find useful. This project will also result in increased transit industry knowledge of how to incorporate social media with the most effectiveness.

Program Goal: Customized Services that Expand Ridership

Research Phase: Baseline Assessment

Project Fiscal Year(s): 2010

13. Investigate Technology's Role in Transit use by Older Populations

Purpose: To build on previous FTA work regarding transit options for the Nation's mature and elderly populations by focusing specifically on the role of technology in providing accessible and appealing services.

Approach: This project has two components: the first focus of the activity will be to work with universities, associations, and other federal agencies concerned with the needs of this population to understand the gaps in technology usage among these populations and describe technologies that would be more appealing for them to use in accessing transit services and traveler information; the second focus of the activity will be to inform and enable the agencies providing services to use technology to operate most efficiently.

Deliverables/Outcomes: Strategies for using technology to better reach and serve the Nation's mature and elderly populations. This project will also result in descriptions of technology needed by transit agencies serving these populations and recommendations for future investments.

Program Goal: Accessible Services for All Populations

Research Phase: Baseline Assessment

Project Fiscal Year(s): 2010

14. Develop Accessibility Guidelines for Traveler Information Systems

Purpose: To develop guidelines for transit agencies on providing traveler information that is accessible in its delivery methods and meets the needs of special populations.

Approach: The FTA will build upon previous work at universities, associations, and agencies to develop guidelines that address the needs of special populations. Further research will identify accessibility gaps in current traveler information systems and make recommendations for improvement. The project will consider both the delivery mechanisms for traveler information (i.e., medium, presentation through colors or layout, etc.), as well as the content (i.e., inclusion of paratransit and demand-responsive services in traveler information systems).

Deliverables/Outcomes: Guidance to agencies on how to provide accessible traveler information.

Program Goal: Accessible Services for All Populations

Research Phase: Development

Project Fiscal Year(s): 2011-2012

15. Barriers to ITS Adoption

Purpose: Identification of barriers to ITS adoption (institutional issues).

Approach: Through stakeholder engagement and interviews, the FTA will determine what barriers exist that prevents widespread adoption of ITS technologies by the public transportation industry and how they can be overcome. Input will create a greater understanding of the ongoing issues related to ITS deployments that may be helped through professional capacity building, peer technical assistance, or other guidelines and will help inform how to most effectively leverage the investments planned within this five-year plan.

Deliverables/Outcomes: A set of strategies to eliminate or reduce the barriers.

Program Goal: Program Management

Research Phase: Baseline Assessment

Project Fiscal Year(s): 2011

Appendix E. Official Transit Social Media Sites

The Transit Wire list of transit-related Social Media was accessed on August 10, 2010 at <http://www.thetransitwire.com/social-media/>.

As of August 2009, *The Transit Wire* began posting links to official transit agency social networking sites— agency blogs, Facebook pages, Twitter feeds, and YouTube channels. *The Transit Wire* continues to compile its list of links to these official agency sites to share with its readers. This is a work in progress. *The Transit Wire* has requested its readers to provide additional information to enhance this list, include adding new agency pages to the list, providing changes/corrections, or send comment(s) on user experiences with these social networking applications.

Transit agency blogs

- The Buzzer
- Capital MetroBlog
- CDTA iRide Blog
- The Official Blog of the Roads & Transport Authority – Dubai
- Eye on Your Metro Commute
- Intercity Transit’s Blog
- LA Metro Transportation Library and Archive Headlines
- **Los Angeles County Metropolitan Transportation Authority:**
<http://losangelestransportation.blogspot.com>
- Metrolink Linking Communities
- Mile-by-Mile
- Moving LANTA Forward
- NextStop
- Port Authority TransitBlog
- Ride AC Transit
- Santa Rosa CityBus
- SFBART’s blog
- The Source
- Welcome to the Fast Lane
- Write on Metro

Facebook

- AC Transit
- Amtrak
- Bay Area Rapid Transit
- Charleston Area Regional Transportation Authority
- Clemson Area Transit
- Community Transit (Everett, WA)
- CyRide
- Dallas Area Rapid Transit
- Greater Dayton Regional Transit Authority
- Roads & Transport Authority – Dubai
- Escambia County Area Transit
- GO Transit (Toronto)
- Hampton Roads Transit
- Houston METRO
- IndyGo
- Intercity Transit
- Johnson County Transit
- Kansas City Area Transportation Authority
- **Los Angeles County Metropolitan Transportation Authority:**
 - <http://www.facebook.com/home.php#/group.php?gid=10040701921>
 - <http://www.facebook.com/group.php?gid=39632681647>
 - <http://www.facebook.com/group.php?gid=31253356108>
 - LA Metro Regional Connector Transit Corridor Project
 - LA Metro South Bay Metro Green Line Extension
 - LA Metro Westside Subway Extension
 - Lane Transit District (Eugene, OR)

- Lehigh and Northampton Transportation Authority
- Metrolink
- Metropolitan Transportation Authority (NY)
- MTA Bridges and Tunnels
- MTA Long Island Rail Road
- MTA Metro-North Railroad
- MTA New York City Transit
- Mountain Line (Morgantown, WV)
- Orange County Transportation Authority
- Pierce Transit
- Ride Connection
- Sound Transit
- St. Louis Metro Transit
- START Bus (Teton County, WY)
- Tampa Bay Area Regional Transportation Authority
- The Transit Wire
- Triangle Transit (Chapel Hill, NC)
- TriMet
- Tulsa Transit
- Washington Metropolitan Area Transit Authority

Twitter

- AC Transit
- Amtrak
- Bay Area Rapid Transit
- Cincinnati Metro
- Greater Cleveland Regional Transit Authority
- Greater Cleveland Regional Transit Authority Park and Ride
- CyRide
- Dallas Area Rapid Transit
- DART First State
- Roads & Transport Authority – Dubai
- GO Transit
- Greater Dayton Regional Transit Authority
- Hampton Roads Transit
- Houston METRO
- IndyGo
- Intercity Transit
- Johnson County Transit
- King County Metro
- Kansas City Area Transportation Authority
- **Los Angeles County Metropolitan Transportation Authority:**
 - <http://twitter.com/metrolosangeles>
 - <http://twitter.com/metrolibrary>
 - LA Metro
 - LA Metro Transportation Library and Archive
- Lehigh and Northampton Transit Authority
- Metrolink
- Mountain Line
- **Metropolitan Transportation Authority (NY MTA)**
 - MTA Long Island Rail Road
 - MTA Metro-North Railroad
 - MTA New York City Transit — Buses
 - MTA New York City Transit — MetroCard
 - MTA New York City Transit — Subways
- New Jersey Transit
- New York State DOT Twitter Directory
- Orange County Transportation Authority
- Pinellas Suncoast Transit Authority
- Port Authority of Allegheny County
- Reconnecting America
- Regional Transportation Authority – Chicago
- San Francisco Muni
- Santa Rosa CityBus
- Southeastern Pennsylvania Transportation Authority
- St. Louis Metro Transit
- START Bus
- Tampa Bay Area Regional Transportation Authority
- Toronto Transit Commission
- TransLink
- Triangle Transit
- TriMet
- ValleyRide
- Winnipeg Transit (general)
- Winnipeg Transit (alerts)

YouTube

- AC Transit
- Capital District Transportation Authority
- Dallas Area Rapid Transit
- Roads & Transport Authority - Dubai
- Hampton Roads Transit
- Houston METRO
- Johnson County Transit
- **Los Angeles County Metropolitan Transportation Authority:**
 - <http://www.youtube.com/metrolibrarian>
 - LA Metro Transportation Library and Archive
- Lehigh and Northampton Transit Authority
- **Metropolitan Transportation Authority (NY MTA)**
 - MTA Long Island Rail Road
- Regional Transportation Commission of Southern Nevada
- St. Louis Metro Transit
- Transit Authority of River City
- TriMet

Flickr

- Hampton Roads Transit
- Intercity Transit
- Johnson County Transit
- **Los Angeles County Metropolitan Transportation Authority:**
 - <http://www.flickr.com/photos/metrolibraryarchive/>
 - LA Metro Transportation Library and Archive
- MTA New York City Transit
- St. Louis Metro Transit
- TriMet

Other Applications

- Hampton Roads Transit LinkedIn
- LA Metro Transportation Library and Archive Scribd: <http://www.scribd.com/metrolibraryandarchive>
- LA Metro Second Life: Eduland3 (33, 95, 23)
- MTA New York City Transit Podcasts

Sample Social Media Policies

- State of California Social Media Policy
- Blogging at EPA
- Fairfax County (VA) Facebook Comment Policy
- Florida Social Media Toolkit
- List of social media policies on GovLoop
- Missouri Department of Transportation Blog Comment Policy
- North Carolina Social Media Guidelines
- City of Seattle (WA) Blogging Policy
- U.S. State Department Social Media Policy
- State of Utah Social Media Guidelines
- Wake County (NC) Social Media Guidelines

Appendix F. Timeline of Regulatory Changes that Affect Private Radio Systems

Table 12: Timeline of Regulatory Changes that Affect Private Radio Systems

Year	Regulatory Change
1997	UHF/VHF Equipment Manufacturers: New Equipment Certification: FCC will only certify new VHF and UHF equipment capable of using 12.5 kHz bandwidth or less for voice, and 4800 bps per 6.25 kHz bandwidths for data. Dual mode that operates with both 25 kHz and 12.5 kHz channels is acceptable.
	UHF/VHF Users: Radio Service Consolidation The 20 radio services spread among 6 service categories are consolidated into two radio pools: Public Safety Pool; and Industrial/Business Pool.
1998	700 MHz Band: New FCC Service Rules/Transition to Digital TV in 2009 The 24 MHz of spectrum in the 764-776 MHz and the 794-806 MHz frequency bands (collectively, the 700 MHz band) is to be reallocated from television broadcast services to public safety general use and low power 6.25 kHz channels for voice and wideband 50 kHz channels for data and video.
2005	UHF/VHF Equipment Manufacturers: New Equipment Certification: January 1, 2005 (Deadline suspended) FCC will only certify new VHF and UHF equipment capable of using 6.25 kHz bandwidth or less for voice, and 4800 bps per 6.25 kHz for data. Dual mode that operates with both 12.5 25 kHz and 6.25 kHz channels is acceptable.
2008	800 MHz Band: Target Completion of Frequency Re-Configuration: June, 2008 (partially met) Partial completion of re-banding public safety licenses in the 800 band to reduce interference with Sprint's cellular systems. Public Safety will initially be given priority for cleared channels. Full completion expected in the 2011 to 2012 timeframe.
	UHF/VHF Users with Federal Licenses Implement New Efficiency Standards: January 1, 2008 Federal licensees must implement voice channels of 12.5 kHz or less, and data channels with efficiency of at least 4800 bps per 6.25 kHz bandwidths. <i>This may cause interoperability issues with agencies using wider channels</i>
2009	700 MHz Band: Television Vacates Allowing New Public Safety Channels: February 17, 2009 Regional wireless spectrum plans designate which channels within this band are available for Public Safety general use and low power 6.25 kHz channels for voice and wideband 50 kHz channels for data and video.
2011	UHF/VHF Equipment Manufacturers/ Importers: January 1, 2011 Highband VHF and UHF equipment for voice channel widths greater than 12.5 kHz may not be manufactured or imported. NOTE: Newly manufactured radios (e.g., in MY2011 buses) may not work with 25 kHz systems.
	UHF/VHF Users: New and Modified License Applications: January 1, 2011 FCC not accept new applications or modified application for UHF/VHF systems operating on channels greater than 12.5 kHz for voice, and 4800 bps per 6.25 kHz bandwidths for data.
	800 MHz Band: Target Completion of Frequency Reconfiguration Substantial completion of re-banding public safety licenses in the 800 band to reduce interference with Sprint's cellular systems. Public Safety will initially have priority for use of the cleared channels.
2013	UHF/VHF Users: New Efficiency Standard Mandate becomes Effective, January 1, 2013 All licensees must implement equipment with voice channels of 12.5 kHz or less, and data channels with efficiency of at least 4800 bps per 6.25 kHz bandwidths. (Exception for 152.0075 and 157.450 MHz "paging-only" channels.)
2018	UHF/VHF Users: FCC Goal for Implementation of More Stringent Efficiency Standards (Deadline suspended) All licensees must implement equipment operating with voice channels of 6.25 kHz or less, and data channels with efficiency of at least 4800 bps per 6.25 kHz bandwidths.

Accessed from CTAA (Community Transportation Association of America (CTAA)) website at http://web1.ctaa.org/webmodules/webarticles/articlefiles/Timeline_Regulatory_Changes.pdf on February 2, 2010.



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