TCRP REPORT 92

TRANSIT COOPERATIVE RESEARCH PROGRAM

Sponsored by
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Strategies for Improved Traveler Information

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP REPORT 92

Strategies for Improved Traveler Information

MULTISYSTEMS, INC.
Cambridge, MA

SUBJECT AREAS
Public Transit

Research Sponsored by the Federal Transit Administration in Cooperation with the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2003
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TRANSIT COOPERATIVE RESEARCH PROGRAM

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

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

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA; the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

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Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

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

TCRP REPORT 92

Project A-20A(2) FY'02
ISSN 1073-4872
ISBN 0-309-08761-9
Library of Congress Control Number 2003108162

Price $22.00

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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TRANSIT COOPERATIVE RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at
http://www.national-academies.org/trb/bookstore

Printed in the United States of America

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AUTHOR ACKNOWLEDGMENTS

The research reported herein was performed under TCRP Project A-20A(2) by Multisystems, Inc.; Charles River Associates, Inc.; the Texas Transportation Institute; and Ankerbold International, Ltd., contributed to and prepared portions of this report based on their prior work on TCRP Project A-20A. Carol L. Schweiger of Multisystems is the Principal Investigator for this study.

The authors of this report are Carol L. Schweiger and Khaled Shammout of Multisystems, with assistance from Sean Peirce, Mark Kiefer, and Michael Kemp of Charles River Associates; Mark Hickman of the Texas Transportation Institute; and John Miles of Ankerbold International.

FOREWORD

By Christopher W. Jenks
Staff Officer
Transportation Research Board

This report will be of use to transit managers and others interested in improving transit traveler information for current and potential customers. It provides a useful summary of the state of the practice in the area of improved transit traveler information. The report identifies transit traveler information needs, assesses the state of the art in providing transit traveler information, provides examples of customer information systems from both inside the transit industry and related industries, discusses transit traveler information as part of larger community information systems, and offers new directions for the transit industry in providing traveler information.

A workshop seeking new paradigms for public transportation conducted by TCRP identified timely traveler information as a key feature of a successful transit system. Changing demographics and technological progress are raising expectations. Today's transportation consumers must manage their time effectively, and significant uncertainty associated with waiting for a bus or train is unacceptable to most people. Providing information to give travelers greater control over their time is a paradigm shift. Also, many consumers are unaware of all of their public transportation options. The use of information-based technologies can expand traveler choices and facilitate delivery of more convenient services, potentially increasing transit ridership.

Under TCRP Project A-20A(2), research was undertaken by Multisystems, Inc., to identify strategies for using information technology to assist individual mobility-related decisionmaking. The focus of the research was on how public transit providers can most effectively provide transit traveler information, specifically, on how public transit agencies can take maximum advantage of new and emerging technologies to better inform travelers about mobility choices.

To achieve the project objective, the researchers collected, reviewed, and updated information on the state of the art of transit traveler information systems. Information was collected on current efforts by transit systems, both domestic and international, to improve their traveler information systems. The researchers also obtained information on the experience of other industries in providing customer information. Specifically, information was collected from the airlines and other industries that provide real-time customer information via telephone, cellular telephone, alphanumeric pager, personal digital assistant, and e-mail; package delivery companies that provide customer information via the Internet; companies that provide location-based content services or portable information using technologies such as global-positioning-system mobile phones; and companies that provide real-time itineraries, including directions, on mobile devices.

The researchers then examined how advanced traveler information systems for transit can be part of community-based information networks. Examples of such systems implemented in Europe were reviewed. Finally, the researchers examined how transit systems in the United States can learn from the experiences of (1) public transit agencies in other countries, particularly in Western Europe, that have embraced and provide real-time customer information using a variety of dissemination media; and (2) other industries that provide customer information using innovative techniques. Potential new directions for transit traveler information were then developed.

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SECTION 1

INTRODUCTION

1.1 PROJECT PURPOSE AND OBJECTIVES

Providing improved transit traveler information (TTI) has advanced significantly over the past 10 years with the advent of new technologies, such as automatic vehicle location (AVL) and advanced communications, and of new dissemination mechanisms and media, such as wireless application protocol (WAP), mobile telephones, and personal digital assistants (PDAs). Today, transit travelers—particularly choice riders—expect to have comprehensive information about multiple modes (including traffic information) available to them quickly, in one place or from one source, and on a variety of media. Transit agencies are being challenged to meet these travelers' needs, given declining budgets and the continuing need to provide efficient service. Paper schedules, manually operated customer information telephone services, and the need for travelers to make several telephone calls to obtain information will no longer satisfy travelers. Furthermore, transit agencies are exploring new ways to maintain existing riders and to attract new riders. Providing static and real-time transit information using new strategies is becoming a priority in many transit agencies around the world. These strategies include the use of technologies such as the Internet, dynamic message signs (DMSs), and wireless mobile devices and the redesign of traditional transit materials, such as bus schedules, to make them more user-friendly.

This new era of providing improved TTI is analogous to the new paradigm for public transportation, as described in *TCRP Report 58: New Paradigms for Local Public Transportation Organizations* (*1*). To date, transportation has been viewed on a mode-by-mode or stovepipe basis, with each individual mode providing its own services and information, measuring its own performance, and rarely coordinating with other modes. This arrangement is analogous to travelers having to consult multiple nonintegrated sources of traveler information to plan a trip. The new paradigm, which supports the idea of true intermodalism, views transportation from the user's perspective rather than from the agency's perspective. In this perspective, the user does not see individual agencies providing individual services and information, but rather views multiple modes as providing one integrated service. This arrangement is analogous to travelers consulting one integrated source of traveler information to plan and take a trip. The new paradigm effort also states that "information technology provides the single greatest opportunity to enhance the quality of the travel experience" (*2*).

To strengthen this analogy, the European Commission's white paper entitled "European Transport Policy for 2010: Time to Decide" discusses the "continuity of journeys" as one of several key areas for improvement (*3*); this concept involves not only improving the coordination of transportation services provided by several modes, but also improving passenger information by providing integrated information and payment services. This concept of improving passenger information was also highlighted in the European Commission's green paper entitled "The Citizen's Network—Fulfilling the Potential of Public Passenger Transport in Europe" (*4*).

Finally, the new congestion charging program that went into effect in London on February 17, 2003, is reliant on improvements in public transportation that were outlined in the Mayor of London's transportation strategy of July 10, 2001 (*5*). In 2 of the 10 priorities outlined in this strategy, there are specific references to improving information about public transportation as a way to improve London's transport system.

The objective of this research was to identify strategies for using information technology to improve individual mobility-related decisionmaking. The project's focus was on how public transportation providers can most effectively provide TTI, specifically, on how public transportation agencies can take maximum advantage of new and emerging technologies to better inform travelers about mobility choices. The research identified traveler information needs, assessed the state of the art in TTI systems, and developed a number of case studies in the area of improved traveler information.

To fulfill the primary objective of this research, this report presents a summary of existing practice in the area of improved traveler information. Examples are given of how public transportation providers can become part of region-based and/or community-based information dissemination systems that include—but are not limited to—hand-held, vehicle-mounted, kiosk-based, and web-based communications. The summary will provide information on the following:

- The demand for TTI,
- The state of the art in providing TTI,
- Examples of providing customer information in related industries,
- TTI as part of community information systems, and
- New directions for transit in providing traveler information.

Work accomplished as part of three related projects provided valuable and complementary input for this research:

1. *TCRP Synthesis 48: Real-Time Bus Arrival Information Systems,* which is the final product of TCRP Project J-7 Synthesis Topic SA-14, documents the state of the practice in real-time bus arrival information systems, including both U.S. and international experience (*6*).
2. An FTA project entitled "Real-Time Transit Information Assessment" is to identify and document successful implementations of real-time transit information systems and to provide guidance to agencies that are considering such systems. As of the publication of this report, a white paper describing the literature search and review has been published; the site visits and telephone interviews have been conducted; and a guidance document describing recommended practices in deploying real-time transit information systems has been drafted.
3. Another FTA project, "Advanced Traveler Information Systems (ATIS) Human Factors Assessment," is being conducted to determine the following:
   - What transit information travelers want, including the type of information and message content;
   - What the preferred communications channels (media and devices) are by which to provide the information;
   - What the preferred locations are for providing the information;
   - What the preferred temporal and situational aspects of the information are (when to provide the transit information);
   - What are the impacts of and what constitutes unreliable information; and
   - What are the recommended design characteristics for effectively presenting transit information via the preferred communications channels.

   The final product of this project will be guidance to transit agencies in providing transit information to the public via advanced technology in the most effective and preferred manner from the customer's viewpoint. As of December 2002, workshops were held around the country to determine the needs, attitudes, and preferences of transit users and nonusers for TTI. The final FTA report is expected to be available in Summer or Fall 2003.

1.2 STUDY WORK PLAN

The work plan for this project consisted of six tasks, which are described as follows.

1.2.1 Task 1: Update State-of-the-Art Information

The first task was to collect and update information on state-of-the-art TTI systems. The basis of updating this information was current literature; survey responses from *TCRP Synthesis 48: Real-Time Bus Arrival Information Systems* (*6*); information obtained from the previously mentioned FTA project on real-time transit information systems assessment; other relevant projects conducted by Multisystems (e.g., TCRP Project J-9 Task 4 [*7*]); and information from other relevant projects (e.g., Volpe National Transportation Systems Center's Transitweb [*8*]; A Thematic Long-term Approach to Networking for the Telematics and ITS Community [ATLANTIC]; the ATIS research conducted for Transport Direct [in the United Kingdom]; the TRansport Intermodality Data sharing and Exchange NeTwork [TRIDENT] project; and the Institute of Logistics's project entitled "Public Transport Information Web Sites: How to Get It Right" [also in the U.K.]).

Other sources of information that were reviewed for this report include the following:

- A summary of information provided in FTA's *APTS: The State of the Art—Update 2000* and *APTS Deployment in the U.S.—Year 2000 Update* reports (*9, 10*);
- Agencies that provide real-time and static transit information via PDAs, mobile telephones, and the Internet (e.g., King County Metro's MyBus, Secondkiss™, ShuttleGirl™, Zero-Sixty Corporation's Concourse™, and Nottingham City Transport's [in the U.K.] next bus text messaging);
- Agencies that provide real-time transit information for a specific bus stop (e.g., Portland's Tri-County Metropolitan Transportation District of Oregon [Tri-Met] and the $\text{SMART}_{\text{TRAC}}$ system at the San Joaquin Regional Transit District); and
- Agencies that provide real-time arrival and departure information at the bus stop, transit center or station, or both.

1.2.2 Task 2: Summarize Experience of Other Industries in Providing Customer Information

The second task consisted of collecting information on the practices of other industries in providing customer information. This information was collected by conducting telephone interviews with key personnel in several other industries and by conducting web searches. The industries contacted included the following:

- Airlines and other industries that provide real-time customer information via phone, cellular telephone, alphanumeric pager, PDA, and e-mail (e.g., American Airlines Flight Status Notification system, the Weather Channel's My Weather—Get Weather Anywhere®, and Notify! by the Weather Channel);
- Package delivery companies that provide customer information via the Internet (e.g., United Parcel Service InfoNotice℠, Federal Express InSight℠);
- Location-based content services/portable transit information (e.g., global positioning system [GPS] mobile phones, Vindigo, GeePS, go2Systems); and
- Real-time itineraries, including directions, on mobile devices.

1.2.3 Task 3: Summarize Transit's Role in Community Information Systems

An examination of how ATISs for transit can be part of community-based information networks was also conducted. For example, in Nottinghamshire County, U.K., a traveler information system called "TravelWise Nottingham" is provided on the Internet: "The purpose of the Travelwise Centre is to provide extensive traffic and travel information to the residents of Nottinghamshire who wish to explore and use alternatives to travelling alone by car" (*11*). The information is available via the Internet, local radio broadcasts, a telephone hotline, and publications. This system is a partnership of the City of Nottingham, the U.K.'s Highways Agency, the Nottinghamshire County Council, and BBC Radio Nottingham.

1.2.4 Task 4: Identify Potential "New Directions" in TTI

In recent years, more transit agencies in the United States are providing TTI using the latest technology. While many agencies are beginning to embrace a customer focus, there is still reluctance from some agencies to address customer information needs. Agencies typically deploy technology to improve internal operations first and customer service second. Since the deployment of real-time customer information is based on the successful deployment of systems that improve internal operations, agencies tend to focus most of their efforts on these backbone systems.

The purpose of this task was to determine how transit can learn from the experiences of (1) public transportation agencies in other countries, particularly in Western Europe, that have embraced and provide real-time customer information using a variety of dissemination media, and (2) other industries that provide customer information using innovative techniques.

1.2.5 Task 5: Prepare and Submit Draft Final Report

A preliminary draft final report was submitted for review by the project oversight panel.

1.2.6 Task 6: Prepare and Submit Revised Final Report

Based on panel comments received on the draft, a revised final report was prepared.

1.3 REPORT ORGANIZATION

The report is organized as follows:

- Section 2 provides a review of the literature on the subject of TTI;
- Section 3 describes the demand for TTI;
- Section 4 presents the state of the art in TTI;
- Section 5 identifies and describes key TTI systems in existence in the United States and Europe;
- Section 6 provides a summary of customer information provision from industries outside of the public transportation realm;
- Section 7 discusses TTI as part of regional and community-based information systems; and
- Section 8 provides a discussion of strategies that transit should consider taking advantage of new and emerging technologies and techniques to better inform travelers about mobility choices.

Throughout the report, key resources are noted, including Internet website addresses. Please note that website addresses are subject to change; where an address is noted, the date when the address and content was valid also been included.

1.4 REFERENCES AND ENDNOTES FOR SECTION 1

1. *TCRP Report 58: New Paradigms for Local Public Transportation Organizations—Task 5 Report: Opening the Door to Fundamental Change,* Transportation Research Board of the National Academies, Washington, DC: 2000: http://trb.org/trb/publications/tcrp/tcrp_rpt_58.pdf.
2. *TCRP Report 58,* p. 15.
3. European Commission. "White Paper: European Transport Policy for 2010: Time to Decide," European Communities, 2001; http://europa.eu.int/comm/energy_transport/library/lb_texte_complet_en.pdf.
4. European Commission. "Green Paper: Fulfilling the Potential of Public Passenger Transport in Europe," COM(95)601, November 1995: http://europa.eu.int/en/record/green/gp001en.pdf.
5. K. Livingston. *The Mayor's Transport Strategy,* July 10, 2001.
6. Schweiger, C.L. *TCRP Synthesis 48: Real-Time Bus Arrival Information Systems.* Transportation Research Board of the National Academies, 2003.
7. *TCRP Report 84: e-Transit: Electronic Business Strategies for Public Transportation, Volume 4: Advanced Features of Transit Websites.* Transportation Research Board of the National Academies, 2003.
8. http://transitweb.volpe.dot.gov/
9. Casey, R. F., L. N. Labell, L. Moniz, J. W. Royal, C. L. Schweiger, M. Sheehan, T. Sheehan, A. Brown, M. Foy, M. Zirker, J. B. Marks, B. Kaplan, and D. Parker. *Advanced Public Transportation Systems: The State of the Art—Update 2000,* DOT-VNTSC-FTA-99-5 and FTA-MA-26-7007-00-1, FTA/Office of Mobility Innovation, December 2000; http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13583.pdf.
10. Casey, R. F. *Advanced Public Transportation Systems Deployment in the United States—Year 2000 Update,* DOT-VNTSC-FTA-02-06 and FTA-MA-26-7007-02.1, FTA/Office of Mobility Innovation, May 2002; http://www.itsdocs.fhwa.dot.gov/JPODOCS/ REPTS_TE/13680.html.
11. http://utc.nottscc.gov.U.K./index.htm.

SECTION **2**

LITERATURE REVIEW

An initial step in studying strategies for improved traveler information was to conduct a comprehensive literature search and review. The literature review for this project included reviewing papers, reports, and articles about ATIS, TTI, and the underlying transit intelligent transportation systems (ITS) technologies from numerous sources. These sources included the following:

- Intelligent Transportation Society of America (ITSA) annual meetings proceedings;
- ITS World Congress meetings proceedings;
- TRB annual meetings papers;
- Transportation Research Information Services (TRIS);
- FTA, FHWA and ITS Joint Program Office reports;
- Related TCRP projects (including Synthesis projects);
- Interviews with nontransit companies that provide innovative customer information systems;
- Documentation from numerous European Commission and U.K. studies about ATIS and TTI systems; and
- Key TTI websites from the United States, Canada, Europe, and Asia.

The literature review also included reviewing interim material and reports from TTI-related projects currently being conducted by FTA's Office of Mobility Innovation, including the real-time transit information assessment and ATIS human factors assessment projects. FTA's Real-Time Transit Information Assessment project included conducting telephone and on-site interviews with a total of 10 transit agencies that have deployed or are deploying real-time information systems. Information from these interviews provided significant insight into the deployment of TTI; where appropriate, this information is included in Sections 4.2 and 5 of this report.

Further, two TCRP projects conducted by Multisystems have generated reports that were reviewed for this project. These projects are TCRP J-09, "e-Transit: Electronic Business Strategies for Public Transportation, Topic 4: Customer Information," (*1*) and TCRP Project J-7, Synthesis Topic SA-14, "Real-Time Bus Arrival Information Systems" (*2*). Transit agency interviews were conducted as part of these projects as well, focusing on advanced features of transit websites in TCRP Project J-09, Task 4, and on the provision of real-time bus arrival information in TCRP Project J-7, Synthesis Topic SA-14. Relevant information from these projects has been used where appropriate in this project.

One key result of the literature review and experience conducting the aforementioned FTA and TCRP projects was that there is a great deal of activity in the area of providing real-time TTI. Transit agencies are becoming more sensitive to customers' needs for up-to-the-minute information and, consequently, are more interested in adopting the necessary underlying technologies. Most agencies are no longer satisfied by merely providing static information on their Internet sites. They have been very diligent in making their websites more appealing, user-friendly, and useful, and some have begun to provide real-time information via their websites and wireless media.

The literature review also revealed the large number of hardware, software, and communication tools available to improve the provision of TTI and at cheaper rates than ever before. In terms of disseminating TTI, there are now more media available: the Internet, DMSs at bus stops and train stations, mobile telephones using WAP and short message service (SMS), wireless PDAs, and cable television.

Specific key reports are summarized in the following subsections when they contributed to the knowledge of TTI and strategies for improving TTI; however, the literature review was not limited to these documents.

2.1 ADVANCED PUBLIC TRANSPORTATION SYSTEMS: THE STATE OF THE ART—UPDATE 2000

Advanced Public Transportation Systems: The State of the Art—Update 2000, prepared for FTA's ITS/Advanced Public Transportation Systems (APTS) program, provides summaries of U.S. and Canadian transit industries' most innovative and successful applications of advanced technologies (*3*). A significant portion of the report is devoted to TTI systems, including descriptions of pre-trip, en route (also known as in-terminal/wayside), and in-vehicle traveler information systems. Each of these types of systems is described in the report in the Technology Description, Challenges to Implementation, and Application Examples subsections. The technology description discusses the various technologies used in TTI systems and describes the functionalities found in many of these systems. The section on challenges to implementation sheds light on implementation issues, including those related to technological, communications, or financial areas. The application examples for each type of system describe several deployed systems, as follows:

- Pre-trip transit and multimodal traveler information systems:
  - Orange County Transportation Authority (California)—Travel Probe, TravelTIP, and Travel Advisory News Network systems;
  - Washington Metropolitan Area Transit Authority (WMATA) (Washington, DC)—RideGuide;
  - Seattle's King County MetroBusView, MyBus, and e-mail notification;
  - Los Angeles—regional multimodal information integration; and
  - New York City—Service Area Traveler Information Network.
- In-terminal/wayside (also called en route) transit information systems:
  - Miami's Tri-County Commuter Rail Authority Train-Trac system;
  - Eastern Connecticut—coordinated automated announcement system for Shore Line East commuter rail route stations;
  - Long Island Rail Road—Talking Kiosk;
  - San Francisco Municipal Railway—NextBus system;
  - San Francisco's Bay Area Rapid Transit—real-time estimated time to arrival (ETA) in stations; and
  - Seattle's King County—TransitWatch®.
- In-vehicle transit information systems:
  - San Antonio's VIA Metropolitan Transit—integrated in-vehicle information; and
  - WMATA—GPS-based automated annunciation system.

These examples were current as of 2000.

2.2 ADVANCED PUBLIC TRANSPORTATION SYSTEMS: DEPLOYMENT IN THE UNITED STATES—YEAR 2000 UPDATE

Advanced Public Transportation Systems Deployment in the United States—Year 2000 Update, also prepared for FTA, is a compilation of existing and planned deployments of 17 APTS elements (*4*). The information was collected during 2000 and was obtained through contacts with one or more persons at each agency. A total of 572 agencies provided information for this study. In contrast to the APTS state of the art report (*3*), this reports surveys every public transit system in the United States that employs or has plans to employ APTS technologies (i.e., is expected to have operational APTS technologies by 2005), but provides relatively little specific information about the individual systems.

This FTA report reveals that the most widely deployed APTS element (for which data was collected for the entire United States) is automated transit information. Of the 572 agencies surveyed, 291 agencies had operational transit information system and 48 agencies were planning on implementing such a system. Further, the report illustrates that 334 agencies have or will have a pre-trip traveler information system, while 167 have or are planning to have an en route traveler information system. As for in-vehicle traveler information systems, 124 agencies stated that they have or are planning on having one deployed. Finally, the report says that the number of operational TTI systems increased by 506% from 1995 to 2000.

2.3 TRIP PLANNING STATE OF THE PRACTICE

Trip Planning State of the Practice describes the current state of the practice in web-based trip or itinerary planning (*5*). It identifies issues associated with trip-planning system development, identifies costs and benefits of these systems, and makes recommendations for outreach and further research that could assist transit agencies in developing and deploying high-quality trip planners. The report also provides detailed information on the features of the 34 systems that were assessed.

2.4 WHITE PAPER ON LITERATURE REVIEW OF REAL-TIME TRANSIT INFORMATION SYSTEMS

In May 2002, FTA initiated a project to develop a guidance document that would provide practical information to transit agencies and support them in fostering the deployment of real-time transit information systems (for both bus and rail). "White Paper on Literature Review of Real-Time Transit Information Systems" addresses the first step in developing that guidance: literature search and review (*6*). The white paper provides information on the successful implementation of real-time information systems in the United States and abroad. Through a comprehensive literature review, this paper examines the implementation and operation of real-time information systems and identifies the issues and problems associated with providing such information.

2.5 TCRP REPORT 84: E-TRANSIT: ELECTRONIC BUSINESS STRATEGIES FOR PUBLIC TRANSPORTATION, VOLUME 4: ADVANCED FEATURES OF TRANSIT WEBSITES

TCRP J-09, "e-Transit: Electronic Business Strategies for Public Transportation, Topic 4: Customer Information" documents the best practices associated with providing customer information via the Internet in *TCRP Report 84, Volume 4* (*1*). The website features that are the focus of this project are automated itinerary planners (AIP), real-time information display systems, electronic notification systems, and customer relationship management (CRM) systems. The eight case studies were developed from detailed website reviews and from extensive telephone interviews with transit agencies that have AIP systems on their websites. Further, providing real-time information and e-mail notification via websites was examined, with a focus on system design and functionality, implementation issues, outcomes and benefits, and planned improvements. General concepts and concerns related to specific technology and application issues were described, crosscutting issues of advanced transit website features were discussed, and best practices and recommendations for further research were identified.

2.6 TCRP SYNTHESIS 48: REAL-TIME BUS ARRIVAL INFORMATION SYSTEMS

TCRP Synthesis 48 describes and documents the state of the practice in real-time bus arrival information systems, including both U.S. and international experience (*2*). A survey was conducted to obtain information on relevant technical capabilities, agency experience, cost, and bus rider reactions to these information systems. This synthesis also includes a review of the relevant literature and focuses on current practice in the field. An important element of this report is the documented interviews with key personnel at agencies that have implemented these types of systems.

2.7 TCRP SYNTHESIS 43: EFFECTIVE USE OF TRANSIT WEBSITES

TCRP Synthesis 43: Effective Use of Transit Websites describes the current practices and experiences in transit website design, content, marketing, and administration (*7*). Information was collected from 47 U.S. transit agencies via surveys and interviews with transit website managers and from other sources, such as logs of website usage, market research conducted by transit agencies, and relevant literature. The report provides information regarding general planning and expectations, priorities for website content, audience needs, marketing and promotion, design parameters, homepage and inside pages design, and website testing and usage monitoring.

2.8 INFOPOLIS PROJECTS

The European projects Infopolis 1 (conducted in 1996–1997) and Infopolis 2 (conducted in 1998–2000) provide significant insight into TTI systems. The primary goal of Infopolis 1 was "to improve user accessibility to Public Transport information in terms of its presentation as well as its content, and to produce guidelines for European Standards for Human Computer Interface" (*8*). Infopolis 1 produced a significant amount of documentation, including a detailed review and analysis of 53 public transport information systems in Europe that were in operation or being implemented in 1996.

Infopolis 2 was an extension of Infopolis 1, and its primary goal was "to improve user access to electronic intermodal traveler information by developing guidelines for the presentation of information" (*9*). Infopolis 2 also generated many documents, some of which were reviewed as part of the literature review for this project. More than 150 European public transportation information systems were investigated, and almost 100 were surveyed. As in Infopolis 1, a detailed review was conducted of the surveyed systems.

2.9 PUBLIC TRANSPORT INFORMATION WEB SITES—HOW TO GET IT RIGHT: A BEST PRACTICE GUIDE

A comprehensive guide, *Public Transport Information Web Sites—How to Get It Right: A Best Practice Guide* focuses on how to present various types of TTI to website users (*10*), ensuring that a TTI website meets the users' needs and is easy to use. This guide is divided into five major sections:

1. Principles of a user-focused approach;
2. Definition of key usability principles;
3. Identification of web TTI elements, or the "toolkit";
4. Examples of good and not-so-good websites; and
5. Site provider's perspective in developing a TTI website.

2.10 REFERENCES AND ENDNOTES FOR SECTION 2

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SECTION **3**

DEMAND AND DESIRE FOR TTI

3.1 EMPIRICAL EVIDENCE CONCERNING THE DEMAND FOR TRAVELER INFORMATION

The evidence on consumer preferences and valuations for public transit information comes from a broad spectrum of research, ranging from qualitative studies to quantitative research based on stated-preference and revealed-preference data. Aspects of customer acceptance for ITS consumer products and services have been studied by U.S. DOT's ITS Joint Program Office since the early 1990s. A major focus of this research was on ATISs, including information for existing and potential transit customers. Evaluations have been conducted of transit information–oriented deployments as part of federally supported field operational tests, the Metropolitan Model Deployment Initiative (MMDI) projects, and local transit ITS deployments. Customer satisfaction information from the MMDI programs in Phoenix, San Antonio, and Seattle was reviewed for this project, as was customer research from other local ITS deployments in the United States and Europe.

3.1.1 Interest in Advanced Traveler Information

It is readily apparent that, while many urban residents express strong dissatisfaction with traffic delays and other traffic problems, many people view those types of irritations quite fatalistically. In focus groups composed of members of the general population, commuting horror stories were heard many times, but the stories were accompanied by a belief that these experiences are an inevitable adjunct to urban living, that nothing much can be done about them, and that it is not worth getting agitated about. "There's death, taxes, and traffic," one person said early in the qualitative research.

These attitudes help to explain why, despite complaining about individual bad situations, the national surveys have shown relatively high levels of overall satisfaction with transportation system performance and a slight belief that things are improving. They also explain why people generally do not appear to be highly motivated to seek sources of traffic and travel information that are currently available to them. Many cities have websites and telephone information services that provide more detailed and up-to-date traffic information than is available from broadcast radio and television stations (the most popular source of information). These newer resources are becoming more sought after or used as time goes by. However, the broadcast media have a considerable advantage of providing very easy and immediate ("one stop") access and do not require the user's full attention. As a result, the various private-sector interests involved in generating, processing, and retailing new forms of traffic information have had difficulty in developing business models to date that make money from anything but the longstanding, brief radio/television broadcast slots and public-sector contracts (*1*). The dissatisfaction expressed with daily travel delays does not automatically translate into streams of revenue from ATIS users. Traffic and travel information has not proved so far to drive the demand for other ATIS products, and a self-sustaining business model for this information is lacking in the United States (*2*). However, as of December 2002, every state in the union has at least one Internet site that provides information on traffic conditions (and can be accessed through the National Traffic and Road Closure Information Internet site at www.fhwa.dot.gov/trafficinfo/#TRFF).

This level of apathy among the public at large does not mean that advanced traveler information has no constituency or that it will not ultimately succeed in proving its worth. There are groups of users that have been identified and surveyed who are strongly enthusiastic about this type of information. They tend to be, as might perhaps be expected, younger, better educated, and better paid than most of the population. They are more "wired" to high-technology devices. They tend to include more males than females. Information about these users is discussed in Section 3.2.2.

Moreover, recent evidence suggests that awareness of ATIS resources is growing, more strongly through the Internet than through telephone information services. As access to the Internet increases markedly, so do people's expectations of the types of information and assistance available to them. Many new users of web-based traveler information say that they went looking for it, expecting it to be there but not knowing where to look other than by using a general search engine. The most informative and popular websites, such as the one provided by the Washington State DOT showing the Seattle-region traffic conditions (www.wsdot.wa.gov/pugetsoundtraffic/), have shown a healthy growth in "hits" and have received very positive feedback from users (*3*).

It is expected that such awareness and usage will continue to grow, driven in part by increased Internet access and use and in part by public awareness of the next (critical) generation of in-vehicle navigation devices, ones that will be able to receive and process real-time traffic information. While the demand for the current generation of static devices, which are available in an increasing number of automobiles, has not been particularly strong, the automakers are hoping to drive demand by supply-side decisions.

3.1.2 Interest in Transit Information

While the subject of this subsection so far has been mostly about traffic information, many of the observations have strong transit parallels. Research on transit information is sparser than on traffic information, but many of the same attitudes can be discerned. Some of the observations presented here were derived from transit-oriented ATIS focus groups in New York City and the Bay Area and from surveying transit information and website users in Seattle and the Bay Area (*4, 5*).

Many bus delays are caused by traffic conditions, and to some extent this helps create the same mixture of customer fatalism and tolerance evident in the discussions of traffic problems. There is an initial skepticism that more or better information can do much to resolve the major sources of dissatisfaction with particular transit experiences. But when the general complaints about transit services have been voiced, it is possible to get people to concentrate on information specifically, and six consistent themes emerge:

1. Customers would like timely and honest explanations of delays when systems fail to operate as they should.
2. Information materials that are currently provided about transit services are not sufficiently detailed for their purpose.
3. Telephone information systems using human operators inevitably attract complaints about the variable quality of the service.
4. More and more transit systems are providing itinerary planning assistance via agency websites and wireless devices.
5. Interest is growing in real-time transit information, and more agencies are providing this type of information.
6. There is evidence that transit information innovations may appeal most strongly to the customers least attached to transit—the choice riders.

3.1.2.1 Explanations of Delays

People have a strong general interest in being given a timely and honest explanation and assessment of the situation when systems are not operating as they should be. This is a concern evident across all forms of public transportation, not just urban transit. Air travel delays and cancellations and the airlines' provision of information to their customers have always been debated (*6*). Passengers can understand such things as weather-related problems, equipment problems, traffic-control problems, and even crew scheduling problems. To varying degrees, they may be somewhat tolerant of these situations. However, they find it much harder to understand and forgive information deficiencies in these circumstances. Experience has taught many frequent flyers to be very distrustful about the information they are given, both because of inadequacies in the airlines' communications systems and because they perceive the information to be slanted in favor of passenger retention concerns (*7*). They know that service disruptions are a fact of life for air travelers, but they expect to be kept accurately informed about the situation so that they can make intelligent decisions about their best courses of action.

One study of the information preferences of public transportation users (both intercity and local) in the Northeast Corridor found that passengers consider information about delays to be important and that passengers tend to value en route information more highly than pre-trip information (*8*). Specifically, 83% of rail transit passengers surveyed rated en route information about train delays to be "somewhat important" or "very important," while 65% said the same of pre-trip delay information. Bus transit passengers held very similar views, with 85% viewing en route information about bus delays as at least "somewhat" important, and 65% saying the same for pre-trip information.

Most research on transit information provision has found that, as with other forms of transportation, even when travelers are unable or unwilling to make changes in their travel as a result of learning about problems, they feel that they still benefit just from knowing about the situation and having been given the option to change, to inform others of a delayed arrival, and so on.

3.1.2.2 Insufficiently Detailed Information Materials

According to transit riders, the information materials that are currently provided about transit services (e.g., maps or schedules, whether displayed at stops, in printed pocket form, or on the web) are not sufficiently detailed for their purposes. The maps do not show all of the road names along the bus routes, for example, or the locations of the individual stops. The schedules do not show the times at all of the stops. The information displayed at individual stops—when it is there at all—is not tailored to help the rider easily answer his or her main questions: "Which routes go from this particular stop? From nearby stops? Where do those routes go? When will the next bus be here?" Or, more succinctly, "How do I get to X from here?"

A qualitative survey of transit users in the Sacramento and San Jose areas examined the areas of transit information judged to be most in need of improvement (*9*). Topping the list of most needing to be improved was the transit route map, with 23% of respondents listing the map as their first choice for improvement. Information on waiting times, hours of operation, and frequency of service were also near the top of the list; while information on fares, walking time to the stations, and seat availability were judged to be less in need of improvement. This "ranking" of the importance of specific types of transit information is reflected in extensive customer research conducted in London regarding TTI over the past 10 years.

3.1.2.3 Variable Quality of Customer Service and Telephone Information Systems

Telephone information systems using human operators inevitably attract complaints about the variable quality of the service. Some operators are very knowledgeable and helpful, but others appear to require a series of questions to obtain the required information; however, talking with a human being often is preferred to listening to a recording.

Telephone menuing systems currently elicit a "love-hate" relationship from their users. Few people profess to like the general "depersonalization" of the telephone, but occasionally admit grudgingly that, despite long menu chains, there are ways to use these systems to get to the desired information quite quickly, if the information is there. The greatest customer dissatisfaction arises from having to wait and navigate through long menus only to find that the service does not answer the current question and does not have the option of diverting to human assistance.

3.1.2.4 Itinerary Planning Assistance via Agency Websites and Wireless Devices

As documented in Section 3.1.1, the last few years have seen a rapid growth in the number of transit systems providing information on the Internet, via wireless devices (e.g., mobile telephones and PDAs), and via electronic signage (e.g., DMSs at stops/stations). Most transit websites provide static information—schedules, system maps, route maps, system policies—and fare information that was previously published by the agency in hardcopy form. Many transit websites now provide itinerary planning, and several provide real-time information (e.g., Denver's Regional Transportation District and Portland's Tri-Met). Transit websites have been the subject of several current and recent projects, including the following:

- *Trip Planning State of the Practice* (*10*);
- *TCRP Report 84: e-Transit: Electronic Business Strategies for Public Transportation, Volume 4: Advanced Features of Transit Websites* (*11*);
- *Public Transport Information Web Sites—How to Get It Right: A Best Practice Guide* (*12*);
- *TCRP Synthesis 43: Effective Use of Transit Websites* (*13*); and
- *Features of Traffic and Transit Internet Sites* (*14*).

When users' opinions have been solicited about transit websites, the responses indicate an interest in itinerary planning assistance. For example, in research conducted on Seattle's King County Metro website in 2000, a large number of respondents indicated that their most pressing need was to get more assistance in planning complex trips to unfamiliar areas. Passengers asked for more detailed maps of bus routes and the neighborhoods the routes serve or, better still, door-to-door itinerary planning (*3*). Since the 2000 survey, the website (tripplanner.metrokc.gov/) provides detailed itinerary planning, as shown in Figure 1.

Users unfamiliar with a transit system do not want to have to follow the cumbersome steps of first determining which routes are relevant to their proposed travel, then consulting individual route timetables in order to identify the schedules and (they hope) specific boarding and alighting points. Rather, users expect to be able to enter their trip origins and destinations, along with a preferred arrival or departure time, and then be presented with a choice of options meeting their criteria. The many transit agencies that now provide itinerary planning on the Internet have fulfilled this need. Not surprisingly, the more complex the transit network in terms of modes, routes, carriers, possible transfer points, and fares, the more valuable this type of assistance becomes.

3.1.2.5 Increasing Interest in Real-Time Transit Information

Opinions about the value of providing real-time transit information show that the interest is growing now that more agencies are providing this type of information. For frequent bus or train services, few focus group respondents initially see much advantage, in the abstract, of having real-time vehicle arrival information available at stops. Greater potential benefits are seen with longer headway services, particularly at night and on weekends. Where such systems have been piloted, most users say they find the information helpful and regard the displays as a sensible use of transit agency funds.

In London, a survey that was carried out when the Countdown system was initiated in 1994 indicated that there was strong interest in the real-time arrival information being provided at bus stops equipped with electronic Countdown signs. The relevant findings of this survey included the following (*15*):

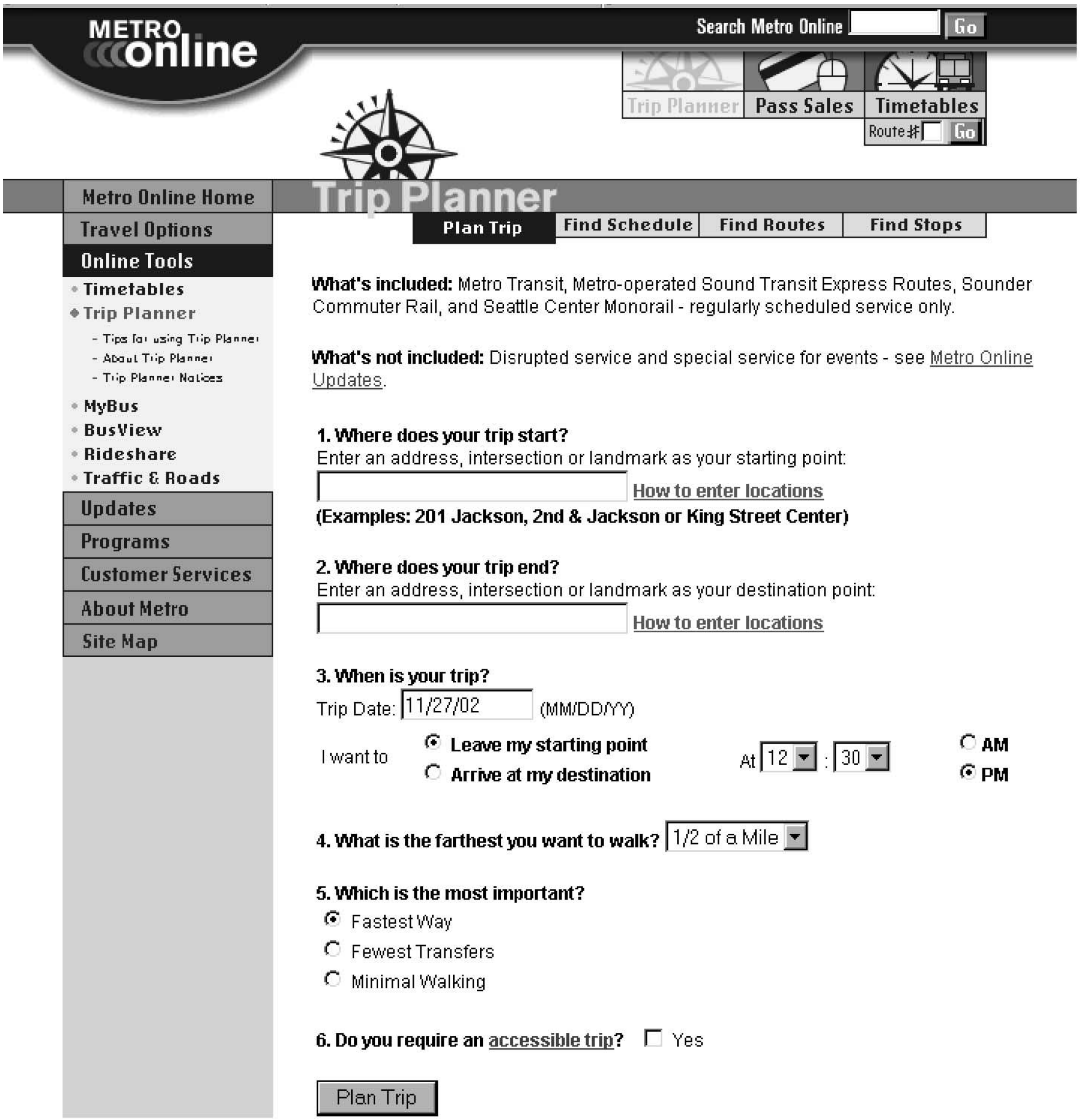


Figure 1. King County Metro's Trip Planner (December 2002).

- With real-time information displayed, passengers felt that waiting for the bus was more acceptable (89% of passengers).
- Passengers found that time seemed to pass more quickly when they knew how long their wait would be (83% of passengers).
- Passengers perceived a shorter waiting time (65% felt this was so).
- The actual bus service was perceived as being more reliable.
- Of those passengers traveling, waiting at night was perceived as being safer.
- Passengers' general feelings improved toward bus travel (68%), the particular operator (54%), and London Transport (45%).
- Almost all passengers (96%) said that countdown information is clear and easy to see and that they have no problem of any kind with the system.
- About 70% of passengers referred to the display when they arrived at the stop, about 90% looked at the sign

while they waited, and about 60% said they looked at the sign at least once a minute.

- Passengers approved of the three essential pieces of information provided (i.e., route number, destination, and waiting time); however, some baseline messages sent by Countdown controllers were not so well understood.
- There was strong overall customer support for the system—Countdown has been found to generate a minimum of 1.5% new revenue.

Also, it is worthwhile to mention that an extensive amount of market research continues to be conducted by London Buses to determine customer satisfaction with the Countdown system and the interest in future enhancements, such as providing real-time information away from the bus stop (e.g., on the Internet or on wireless devices) and the positioning of Countdown signs for best viewing. Key results of recent market research include the following findings.

- Results of 1,125 interviews with passengers waiting at 16 bus stops in northwest London included the following (*16*):
  - On a scale of 0 to 10,
    - Countdown achieved an overall usefulness rating of 7.1;
    - High-frequency stops achieved the best overall rating for usefulness at 7.5; and
    - Countdown was rated the least useful at low-frequency stops at 6.8.
  - Those respondents who had seen Countdown previously were more inclined to value its usefulness, which suggests a learning process.
  - The main reasons that Countdown was considered useful were because it gives arrival time information and it allows passengers to take alternative action.
- Results of seven group discussions in Shepherds Bush, Islington, and Bromley with regular, infrequent, and very infrequent bus users included the following (*17*):
  - Current bus users considered that it was most important to have off-system information available in their homes. Also important were points of interchange with other transport and in supermarkets.
  - There was the most interest in the availability of journey planning information rather than information relating to familiar or regular journeys. More interest was generated in static information than in real-time information.
  - Current bus users thought telephone and Teletext were the most readily acceptable means of communicating off-system bus information.
  - Customers would be prepared to pay a small fee for using any new application, but this fee should be kept to a minimum.

In June 2002, intercept surveys were conducted at four bus stop locations in Portland, Oregon, that have Transit Tracker real-time arrival information displays (*18*) (see Figure 2). The purpose of these surveys was to determine whether changes should be made to Transit Tracker and whether more

Figure 2. Portland Tri-Met Transit Tracker sign.

Transit Tracker displays would be a good value from the customers' perspective. Key survey results reveal that, at one bus stop, "100% of respondents said that they use Transit Tracker, either always (82%) or sometimes (18%)" (*19*). Further, the value that customers place on Transit Tracker was significant and is discussed is Section 3.4.

Several European transit systems have bus stop displays that indicate the amount of time until the next bus on a particular route will arrive. Researchers claim that people regard the waiting times as having decreased after the displays were introduced and that ridership has increased. However, in a survey conducted for *TCRP Synthesis 48: Real-Time Bus Arrival Information Systems* (*20*), many of the agencies indicated that it would be very difficult to ascertain whether ridership increases were solely due to the real-time bus arrival information; rather, it is usually a combination of factors that lead to an increase in ridership after such a system has been deployed. Specific findings from several of the European deployments of real-time information are discussed in Section 4.

3.1.2.6 Transit Information Innovations Appeal Most to Choice Riders

There is some intriguing—but as of yet, only fragmentary—evidence that transit information innovations may appeal most strongly to the customers least attached to transit—choice riders. In the customer satisfaction evaluation of the Seattle Metro TransitWatch real-time displays in bus terminals, there is a correlation between approval of TransitWatch and agreement with the opinion statement "As soon as I can, I'd like to switch to driving" (*21*). Two opposing hypotheses could be derived from this statement, if affirmed by further investigation: (1) that the value of information investments may be reduced by the fact that their appeal is to customers who will desert the mode anyway, and (2) that information investments may help transit to retain the very customers who are most likely to leave. In contrast, in a survey of non-transit users in rural areas across the United States (*22*), respondents showed the most interest in ITS strategies that could help them predict their travel experience: estimates of travel time, information on delays, and real-time bus arrival times. This interest in predictability was consistent with the experience respondents cited with general travel information. Here, the respondents appreciated advance notification of unusual conditions, including delays related to weather, accidents, or construction.

In summary, the initial impression regarding transit customer interest in information improvements is similar to that for traffic information, which provides an appearance of some indifference rather than of immediate and strong enthusiasm. However, based on more detailed research, it is clear that customer expectations are growing with experience (as on the traffic side).

3.2 FRAMEWORK FOR UNDERSTANDING INFORMATION WANTED BY TRANSIT TRAVELERS

In July 2000, Transport Direct—a major U.K. transportation initiative—was announced "to provide the U.K. with a travel information service that can present the public with the opportunity to compare travel options across public and private transport modes" (*23*). As part of this initiative, a comprehensive compendium of research literature and information was compiled to provide the basis for understanding travelers' needs for information, in addition to 12 other topics associated with building such an ATIS. The 13 topics areas are as follows (*23*):

1. Consumer demand for information;
2. Information requirements of the end user;
3. Embracing walk, cycle, and car information;
4. Importance of awareness and marketing;
5. Effects of information on behavior (see Section 3.3);
6. Willingness to pay for information;
7. Importance of partnership and buy-in;
8. Making the business case;
9. Media and presentation formats;
10. Feasibility of including retailing with information;
11. Technical standards and technological solutions;
12. Integration of real-time systems into travel information systems; and
13. Interpreting integration and distinguishing it from coordination.

While the U.K. markets for public transit and TTI are decidedly different than those in the United States, this categorization of key topics provides a solid framework to examine the issues associated with determining the demand for improved TTI. In Subsection 3.2, the demand for TTI will be reviewed in terms of topics: Topics 1, 2, 5, and 6 from the list above. These topics represent the critical elements that should be used in determining what information is desired by existing and potential transit customers.

Before discussing issues associated with demand in each of these topics, it is important to summarize the general demand for TTI, which was initially discussed in Section 3.1 (*24, 25*):

> Transit customers seek to lower the trip time uncertainty they commonly experience with transit. They want information that increases their control over time and travel decisions. Evaluation findings indicate that transit customers want ATIS services that provide real-time information both pre-trip and en route, good quality user interface, and convenient access to detailed system information.
>
> Conditions that suggest high demand for ATIS transit services appear to be related to the complexity of the transit network and services, the age of the transit rider population, and the level of technological sophistication of the ridership.

> Younger riders expect transit information to be as easily accessed as that provided by any market-based service. Their expectations are probably conditioned by the current service economy and by information available on the Internet. Technologically sophisticated riders are aware of many of the tools available for tracking cars and buses and can easily imagine the personal benefits of real-time transit status information, in addition to the other services that advanced media can provide.

3.2.1 Consumer Demand for Information

Demand for TTI must be determined before such a service is even considered. "The general public is not well informed concerning traffic and traveler information and its potential. An insufficiently developed user understanding of traffic and traveler information limits the demand" (*26*). Research conducted for Transport Direct assessed consumer demand for information "to understand how people make use of an information service and how in turn its design can be enhanced both in terms of information content and interface" (*27*). This research highlighted seven specific issues associated with demand that should be factored into a demand assessment:

1. Demand will vary depending upon the mode for which information is being sought;
2. Demand will vary if the TTI service represents more than one mode;
3. Acceptable and maximum levels of demand must be defined;
4. There is a difference between active and passive acquisition of information;
5. There is a distinct difference between providing itinerary planning services and information or guidance on mode choice;
6. Demand for TTI services in the absence of any services is different than demand for TTI services when others services may be available; and
7. TTI features and formats will affect demand.

While all of these factors are important in determining the demand for TTI, two of these warrant further discussion in terms of how to improve TTI.

The first factor is that active and passive acquisition of information (i.e., pull/request and push/alert, respectively) must be fully understood in order to understand the demand for TTI. Several transit agencies now provide "rider alerts" that notify a transit customer of any changes to his or her typical bus route. For example, King County Metro in Seattle provides King County Alert!; users of this e-mail service can select from three options in this system to receive an alert tailored to the user's specific needs:

- **General alerts with no route-specific information**—If the user wants information about changes in multiple bus routes but prefers to limit the number of e-mails he or she receives, this is the best option. He or she will be alerted to service disruptions and advised to check the website for the most current information.
- **"Lite" alerts regarding specific bus routes**—If the user wants information about changes in a specific bus route and has reliable web access, this is the best option. The messages he or she receives will contain a few details and a link to the website for the latest details posted on the Internet.
- **Detailed alerts regarding specific bus routes**—If the user prefers to receive detailed, route-specific e-mail messages, this is the best option. Each message he or she receives will contain detailed information about a specific route.

This type of passive or push/alert information is provided free of charge, depending on the media used for receipt. (If information is received via a mobile telephone, there may be cellular provider charges associated with receiving data.)

Active information requires that the user makes an effort to seek out the information and usually needs to continually refresh the information if it is real-time (*28*). An example of active information acquisition is a passenger sending a text message indicating a specific bus stop via mobile telephone to a telephone number in order to receive a text message that indicates within 30 sec the actual arrival time of the next bus. This real-time TTI service was launched in the U.K.'s Leicestershire County in October 2002 (*29*).

Another example of active information acquisition is receiving the arrival time of the next buses at particular bus stops in Seattle, Washington (www.mybus.org). Yet another example is receiving trip-planning information in the form of text messages from London Transport (*30*). The demand for these two types of information acquisition is quite different, as is the content and medium of providing the information (*31*).

The second factor is that the distinction between itinerary planning and information on a specific mode will drive the demand for TTI. Services that provide information on a specific mode have been evaluated more often than itinerary-planning services using multiple modes since multimodal information services offering itinerary planning have not yet been widely deployed (*32*). In the U.K., a recent survey found that 32% of the general public "often find themselves in a situation when they don't know what is the best means of transport to their destination." Of this group of people, 93% indicated they were likely to use a "single enquiry service giving information about all methods of making a journey" to make decisions regarding the best travel method. In part, demand is likely to be dependent on the extent to which modal alternatives are considered viable when compared with the primary (and default) mode (*33, 34*).

3.2.2 Information Requirements of the End User

Public transit users are a diverse group of people with different demographics, and meeting their needs for information can be challenging. Meeting the needs of individuals can be quite different than meeting the needs of the traveling public. Thus, categorizing individuals is a crucial first step in developing information requirements for TTI services. Several categorizations of end users have been identified in ATIS market research conducted over the last several years. First, the MMDI (*35*) project evaluations categorized overall ATIS customers (not just transit travelers) as follows (*36*):

- **Control seekers**—more likely to be budget conscious, to plan ahead, and to want to be accessible at all times. Characterized by very high use of technology and gadgets (including mobile devices).
- **Web heads**—have a high use of computers and the Internet at home and at work. Usage of mobile devices is low to moderate.
- **Low-tech, pre-trip information seekers**—more likely to make changes in travel patterns as a result of obtaining traveler information.
- **Mellow techies**—low usage of traveler information, but high usage of computers and the Internet.

There is no doubt that these categories could be used to define TTI users. Other categorizations include those identified in research conducted by London Buses Limited (*37*). This research yielded three categories of information users: phobics, lovers, and pragmatists.

No matter which categorization is used, there are other factors that will lead to determining information requirements. Based both on survey research evidence and on detailed consideration of transit travel mechanics and characteristics, a number of different factors can be identified that help determine the types of information that might be desired by transit travelers. Such factors include the following:

- **Stage of the journey.** The type of information needed depends on whether the passenger is planning a trip, is currently en route, or has arrived at an intermediate or final destination.
- **Familiarity with the system.** Tourists and visitors with little knowledge of either the city or its transit system have different needs than locals, even those locals who are only occasional riders. Frequent riders need less information on system policies and services, but are likely to seek out more detailed information on current operations.
- **Trip frequency.** For an infrequent or unfamiliar trip, travelers need more in the way of itinerary planning and basic service information than they do for a commute trip.
- **Nature or purpose of the trip.** The type of trip determines passengers' flexibility with respect to timing, rerouting, making intermediate stops, and so forth. When schedules are tight, such as on business-related trips, travelers may demand more specific, up-to-date information than they would for a weekend shopping trip. And when times and destinations are flexible, passengers will tend to want more information on their alternatives.
- **Accessibility requirements.** These requirements include accommodation for passengers with disabilities as well as provisions for passengers with luggage (*38*) or heavy parcels. Station access—for example, information on the storage of cars and bicycles at stations—is very important for travelers who anticipate driving or cycling to the station.
- **Safety concerns.** For some passengers, knowing where to wait for the train or bus safely, which stations are unattended at night, and so on, are key considerations.
- **Comfort with complexity and technology.** The travelers' level of comfort with complexity will determine whether they would prefer, for example, to receive a single, simplified route to their destinations or more detailed information about all the possible options. Their comfort with technology will also dictate the media through which they prefer to receive the information.
- **Lifestyle and demographics.** The demographics of the user (e.g., income, automobile availability, etc.), the availability of multiple modes, the monetary value of time savings, and personal attitudes toward schedule planning and delays all affect the type of information desired.

Figure 3 represents these eight factors in two main categories: (1) those that are driven by the nature of the journey itself, and (2) those that are driven by the personal characteristics and wishes of the person desiring the information. In addition to these factors, characteristics of the information should be considered as well in determining what kind of TTI is needed or desired by users. These characteristics should include the following (*39*):

- Accuracy—correct information;
- Timeliness—current information, received in time to permit travel changes;
- Reliability—source of information is comprehensive and consistent in quality;
- Costs—both one-time and recurrent;
- Level and personalization of decision guidance—information that is sufficiently detailed and personalized;
- Ease of access of the specific information needed—time required to access information and necessary level of attention; and
- Perceived safety implications—information that protects the user from an insecure or unsafe situation.

The evaluation of TransitWatch, which was conducted as part of the Seattle MMDI evaluation, sought information on how the system could be improved among other customer satisfaction factors. (TransitWatch was the name given to the

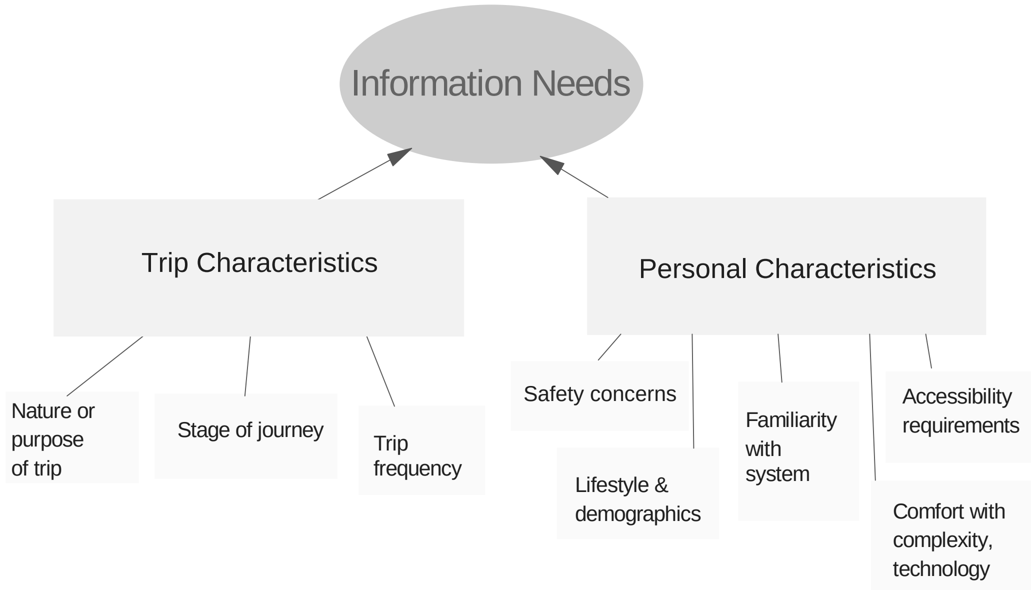
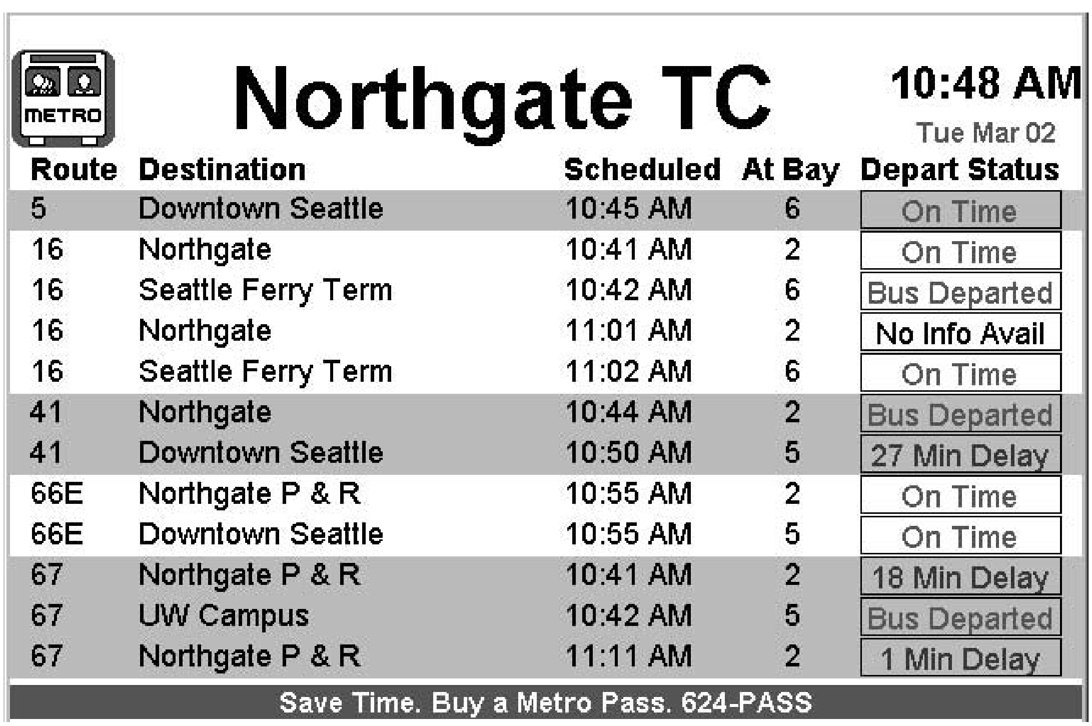


Figure 3. Factors affecting transit passengers' information needs.

video monitors located at the Bellevue and Northgate Transit Centers in the Seattle area that display real-time transit information on arrival times and bus bay locations [see Figure 4].) Those survey respondents who had suggestions about improvements "mentioned improved accuracy the most often" (*40*).

Further, in a web-based transit ATIS evaluation, survey respondents sought the following improvements (*41*):

- Real-time transit information on web, by phone, at bus stops, and on monitors at malls and office parks near major transit centers;
- More sophisticated and detailed web interfaces;
- Point-to-point itineraries;
- Point-to-point itineraries for multimodal trips;
- Recommended trip times and routes for fastest travel;



METRO Northgate TC 10:48 AM Tue Mar 02

Route	Destination	Scheduled	At Bay	Depart Status
5	Downtown Seattle	10:45 AM	6	On Time
16	Northgate	10:41 AM	2	On Time
16	Seattle Ferry Term	10:42 AM	6	Bus Departed
16	Northgate	11:01 AM	2	No Info Avail
16	Seattle Ferry Term	11:02 AM	6	On Time
41	Northgate	10:44 AM	2	Bus Departed
41	Downtown Seattle	10:50 AM	5	27 Min Delay
66E	Northgate P & R	10:55 AM	2	On Time
66E	Downtown Seattle	10:55 AM	5	On Time
67	Northgate P & R	10:41 AM	2	18 Min Delay
67	UW Campus	10:42 AM	5	Bus Departed
67	Northgate P & R	11:11 AM	2	1 Min Delay

Save Time. Buy a Metro Pass. 624-PASS

Figure 4. Seattle TransitWatch® display.

- Detailed maps of routes, with stops, and transfer locations; and
- Secure on-line bus pass purchases.

It is interesting that many of these TTI improvements (with the exception of travel times) have been made around the country at various transit agencies since this evaluation was conducted, most notably in Denver; the San Francisco Bay area; New Jersey; and Washington, D.C.

3.2.3 Effects of Information on Behavior

Quantitative assessment of how the use of information changes travel behavior is still in its infancy, and analysis concerning transit information in particular is especially sparse. There is a little stated preference evidence resulting from direct survey questions about travel changes in response to information acquisition, but there are concerns about whether response biases lead to inaccuracies in such surveys (*42*). For example, in a survey about commuter usage of information designed for the Puget Sound Regional Council, between 24% and 28% of bus and ferry commuters said that they were likely to change their departure time as a result of pre-trip information, 10% to 16% were likely to switch mode, and 11% to 14% were likely to change their routes. Also, mean concurrence with the statement "When waiting, I'm happier if I know when the bus will come" was +3.9 on a scale of −5.0 to +5.0 (this was the highest absolute mean score for any attitudinal statement asked).

Recent research on changes in behavior caused by information suggests that the number of travel alternatives beyond a traveler's primary travel choice drive the change in behavior. This behavior can change in the short-term, long-term, or both. Other research shows that TTI results in mixed and contrary effects on behavior. Most of the research conducted to measure changes in behavior primarily are for traffic information, so it is challenging to make assumptions about the effects of TTI on behavior. The small body of research, including *TCRP Synthesis 48* (*20*), shows that behavior may change for choice riders and that many systems say that TTI systems result in an increase in ridership. However, this resulting change in ridership cannot necessarily be quantified, even though agencies claim an increase.

3.2.4 Willingness to Pay for Information

Several of the previously cited sources indicate that while this subject has been mentioned in the research, the research on willingness for a user to pay for traveler information has yielded mixed messages. In the U.K., various surveys produced stated willingness-to-pay estimates ranging from 0.9 pence ($0.01) to 26 pence ($0.41) per trip. The most reliable of these surveys seems to indicate a valuation of about 9 pence ($0.14) per trip. Overall, the financial projections for London Transport (or Transport for London, as it is now called) indicated a revenue increase of about 1.5% on Countdown-equipped lines and showed the business case to be justified at consumer valuations of about 2 pence ($0.03) per trip and over. Likewise, Helsinki's Promise information program found user valuations to average about 6.5 Euro ($6.48) per month, or 50¢ per request.

It is possible that improved TTI will have to be supported by user fees or fare increases in a declining economy. Because no existing TTI services have a charge associated with them (except for a third-party charge, such as a mobile telephone charge for receiving or sending text messages), it is difficult to assess whether existing and potential transit customers will be willing to pay for improved TTI.

In one particular case in the greater Washington, D.C., area, a provider of traveler information discontinued its telephone-based service after 6 years in operation (its website is still in operation for the D.C. area) (*43*):

> Local governments spent $8 million on SmarTraveler, calling it an essential public service in a region plagued by traffic jams. The money was supposed to cover start-up costs until the private operator could turn a profit. Five other areas also invested millions in SmarTraveler, but all have abandoned it as a profit-making venture.

In 2000, an average of 12,000 phone calls were made per month to SmarTraveler in the D.C. region, which has a population of more than 5.4 million people. By the summer of 2002, the average number of monthly calls dropped to 5,000.

In this case, there was a combination of factors that led to the demise of this service in the D.C. area. First, system users were unwilling to pay for personalized services, such as e-mail or mobile device alerts. Second, users were demanding more detailed and reliable information, which was not being provided by the service because the technology infrastructure was not robust enough. Third, the ability to make a profit was hampered by a lack of advertising and other revenue. SmarTraveler is still in operation in several regions, including Boston and south Florida, because they are funded by public entities.

3.3 WHAT DO TRANSIT CUSTOMERS WANT TO KNOW?

On a practical level, the improved TTI wanted by existing and potential passengers varies most along three of the eight fundamental dimensions shown in Figure 3 (Section 3.2.2):

1. The **type of traveler,** and his or her level of familiarity with the transit service;
2. The **nature of the trip,** primarily in terms of what other travel options (or even nontravel substitutes) may be available to the traveler; and

3. The particular **stage of the journey** (location, point in time, or both) in planning or making the trip at which the information is being sought.

3.3.1 Type of Traveler

Regarding variation by the type of traveler, riders with trips that they make frequently often need little basic (or "static") information about the routes, schedules, transfers, and fares they might encounter in the course of their most customary journeys. It is important to remember, however, that even frequent transit customers may still need information in connection with trips they take infrequently.

On the other hand, very infrequent or neophyte riders may have significant needs for information just to find their way to the appropriate route and stop, to determine schedules and return trip options, to identify the appropriate fare, and so on. For these unfamiliar or less frequent trips, itinerary planning services—detailed, point-to-point directions generated by trip-planning and geographic information systems (GIS) software—can be especially useful. As described in detail in the previous section, such services can be provided via Internet websites, wireless devices, electronic signs at stops or stations, kiosks, or interaction with telephone operators.

It is likely that both frequent and infrequent riders can take advantage of real-time information during their trips—for example, by making use of at-stop displays reporting vehicle arrival times. The primary distinction may simply be in the level of supporting navigational information that will be necessary.

3.3.2 Nature of the Trip

Regarding the nature of the trip, a traveler's information wants may depend on the available options for travel or his or her "degrees of freedom" for the trip. Information content and timeliness needs to be oriented toward the types of alternatives a traveler may consider at different stages of planning or making a transit trip. These types of available options are illustrated in Table 1. Choices of destination, mode, route, departure time, and even whether to take a trip illustrate the "degrees of freedom" available to the traveler. Moreover, those travelers with significant flexibility (or higher degrees of freedom) may need more information in order to make an informed travel decision. A traveler considering options in the time of travel or in the travel mode may a need a great deal of content, in a timely manner, at the point of decision. On the other hand, travelers with little or no travel options may not require the same quantity or detailed level of detail of information as those with greater flexibility.

A different version of this table, showing the relationship between travel characteristics and dissemination media, was produced for the FTA ATIS Human Factors Project discussed in Section 1.1, as shown in Table 2. Also, while information may have a significant effect on helping people make their travel decisions, the overwhelming evidence to date also suggests that both static and real-time information may have significant value to customers even when it does *not* lead to any changes in actual travel behavior. Information may have the effect of simply reducing the potential anxiety of the trip for the traveler. Examples include a passenger calling ahead to announce his or her late arrival, the traveler taking shelter from inclement weather until a time nearer to the

TABLE 1 Choices available to transit customers at various stages of their journeys

Stage of the journey	Type of choice					Information desired	Potential delivery platforms
	Go/no go?	Destination	Mode	Route	Departure time		
Before leaving home on a commute trip	Sometimes	Rarely	X	X	X	Updates on service disruptions, delays	Telephone, cable TV, Internet
Before leaving work for home	Rarely	Sometimes	X	X	X	Updates on service disruptions, delays	Internet, telephone
Before leaving on a trip for non-work purposes	X	Rarely	X	X	X	Point-to-point itinerary planning; operations updates	Telephone, cable TV, Internet
Rail station entry, before paying the fare	X	X	X	X	Rarely	Estimated travel times (including wait and transfer times) to potential destinations	In-station display
Station platform or bus stop	Rarely	X	Rarely	X	X	Vehicle arrival time	At-stop display
Intermediate transfer points	Rarely	X	Sometimes	X	X	Vehicle arrival times, routing information, transfer instructions	Kiosk, at-stop display

TABLE 2 Relationship between travel characteristics and dissemination media

	When / Where			What		How		
	Pre-Trip	Wayside	In Vehicle	Trip Planning	Real-time	Portable	Interactive	Custom
Printed Material	X	X	X	X		X		
Telephone	X			X	X		X	
Cellular Phone	X	X	X	X	X	X	X	
E-mail	X	X	X	X	X	X		X
Handheld Device	X	X	X	X	X	X	X	X
Internet Website	X			X	X		X	X
Kiosk	X	X	X	X	X		X	
Television	X				X			
Video Monitor		X			X			
Message Sign		X	X		X			
Annunciator		X	X		X			

bus's arrival, or the traveler who is just more satisfied with the system because the traveler felt he or she was given an honest and understandable explanation of a delay.

3.3.3 Stage of the Journey

Finally, and perhaps most importantly, information content requirements vary based on the stage of the traveler's journey. The very time consumed by making the trip means that conditions may change while en route, and information content and format need to change as a result. Before setting out, travelers who are planning a trip need information on available travel modes, the location of the nearest stop, and schedule information. Such information is often provided through printed schedules and their online equivalents, but can also be complemented with itinerary-planning services available over the phone or by accessing a website. Those travelers at the bus stop may be concerned about when the bus may arrive or even whether they are waiting for the right bus—information that can be provided by means of at-stop signs or monitors listing bus routes and estimated arrival times. Once on board, travelers may be concerned about the timing of a transfer connection, identifying the alighting stop, or how to get from there to the final destination. Automatic onboard annunciators can provide this kind of stop location and transfer information to passengers.

To identify traveler's information wants or needs, one must look at what information customers would like to know, when, why, and by what means. Tables 3 through 6 illustrate one means of categorizing the desired information. At various stages in their journeys, travelers may need different types of information in various formats. The elements in these tables suggest that people making occasional or infrequent transit trips may need more elementary orientation and navigation information than do regular customers, but both groups can also benefit from "real-time" information about current system performance. Those who travel frequently may have little need for navigation information, but a greater interest in learning about *variations from the expected performance* of the transit service.

3.4 EVIDENCE ABOUT HOW CUSTOMERS VALUE INFORMATION IMPROVEMENTS

As implied in Section 3.2.3, surveys about changes in behavior caused by TTI provide little direct evidence of consumer valuations of specific information enhancements. To find such evidence, other sources need to be reviewed (mostly from Europe). Many European projects (e.g., Italy's Telematics Technologies for Transport and Traffic in Turin) have attempted to quantify valuations through the use of both stated preferences and revealed preferences (i.e., changes in observed behavior).

Trials of the London Bus Countdown system (real-time bus arrival time information displayed on electronic signs at bus stops) provide some evidence on the reactions of transit users to information enhancements. With the Countdown system in place at bus stops along Route 18, mean perceived waiting time fell from 11.9 minutes to 8.6 minutes, and 65% of passengers felt that they waited a shorter time (even though actual waiting times did not change significantly) (*15*). The results of trials for other routes were less dramatic, but even so 21% to 24% of passengers felt that they were waiting less. Other customer surveys have shown that 89% of respondents state that waiting itself is more acceptable at stops equipped with Countdown.

TABLE 3 Sample information desired by transit customers: pre-trip

Occasional Trips	Both Occasional and Frequent Trips
What routes are near my home, work, and other key locations, and what destinations can I reach by transit from those points? Where is the closest stop or station? What are the schedules for the services that stop there? Can I go to an intermediate destination? Is a transfer required? When and how can I get back home? Do I have multiple route or transfer point choices to get to this particular destination? Which will get me there fastest, or most reliably, or with least hassle? When should I leave my trip origin location? How long will I have to wait for service? When will I arrive at my destination? What will the total trip time be, compared with other modes (e.g., walking, cycling, taxi, driving)? How do I get to the station or stop? Is parking available nearby? Are bike racks available? Will I be allowed to take my bicycle on the bus or train? How much will I pay? Overall, how much will it cost compared with other modes? Where and how do I pay? Do I need to use certain forms of payment? Will I be able to navigate the system in a wheelchair, or with a stroller or luggage? Which routes or boarding points will have the fewest obstacles (stairs, faregates with no luggage provision, etc.)? Is the system safe? Are there particular lines or areas to avoid?	Are there disruptions to the usual schedule? How are alternative modes or routes performing today? Can I improve my trip by leaving earlier or later, taking an alternate route or mode, or going first to an intermediate destination? What's the best way to get to the station today (e.g., by walking, driving, cycling)? What will the total trip time be when I travel today, compared with other modes (e.g., walking, cycling, taxi, driving)?

TABLE 4 Sample information desired by transit customers: at station or stop

Occasional Trips	Both Occasional and Frequent Trips
What is the fare? What is the payment system? Do I need to use certain forms of payment? Will I save money by buying other than a single-ride fare? How will I recognize which bus or train is mine?	When will my train or bus get here? Which of the alternative trains or buses currently available here (e.g., different routes, express or local services) will get me there first? Will the next bus or train be less crowded than this one? When will it get here, and when will it get me to my destination? If my bus or train doesn't arrive here on time, should I continue to wait, switch to a different mode, or give up altogether?

TABLE 5 Sample information desired by transit customers: onboard or transferring

Occasional Trips	Both Occasional and Frequent Trips
If I have several transfer point options, how do they compare (travel times, reliability, personal safety, walking distance, comfort, etc.)? How do I navigate at the transfer point or station? Do I need to pay to transfer? How do I obtain whatever I need to prove my transfer validity? When should I start getting ready to alight? Where should I position myself (on platforms, in vehicles, etc.) to make my trip most expeditiously (e.g., maximize my chance of a seat, minimize my connection time, etc.)?	What is causing this delay, and how long will it last? When will my connecting train or bus arrive? How do I navigate the station or system so as to minimize physical barriers?

Passengers also claimed to have waited for a bus indicated at a Countdown stop when they would not have waited at a normal stop, in proportions ranging from 23% to 66%. Between 83% and 93% of interviewees felt that the Countdown system should be introduced on all London routes, and between 53% and 68% of respondents claimed that their attitude toward bus travel had improved as a result of the system.

Surveys of the users of Southampton's Stopwatch project (which provides bus arrival time information via variable message signs at bus stops) indicate that about 3% of riders, on net, plan to use the bus system more often as a result of having this information (*44*). Again, because this is only a stated preference response, it may be unreliable because of noncommitment bias, strategic bias, or other sources of response bias and error. However, it does seem to be supported by the results of other studies. For example, with the introduction of the Phoebus system in Brussels and Angoulème, increased ridership of about 5.8% was observed on bus lines equipped with real-time information about waiting times (*44*). This is consistent with other trials, such as that in Liverpool, in which ridership purportedly increased between 5% and 6% on lines equipped with at-stop displays. Other evidence on consumer response comes from Turin, which has seen a 3% shift in favor of public transport since the introduction of its Telematics Technologies for Transport and Traffic in Turin information system.

The Countdown and Phoebus projects also give some insight into the specific ways in which passengers use and respond to wait-time information. Countdown studies showed that about 90% of passengers look at the sign while waiting and about 60% look at the sign at least once per minute. With Phoebus, studies found that 2% of passengers go back home, 4% decide to walk, and 10% change mode as a result of the at-stop information. Other information relating to the value that customers place on improved TTI can be summarized as follows:

- In the Infopolis 1 project (*45*), users' responses to Countdown and Infobus (in Turin, Italy) indicated that the vast majority (more than 90%) said that they were

TABLE 6 Sample information desired by transit customers: at arrival station

Occasional Trips	Both Occasional and Frequent Trips
Where is my destination relative to the stop or station? What is the best way to get there? Where can I get a taxicab or make another intermodal connection? Can I reconfirm my return trip information? Is there an elevator to street level? Where can I exit to minimize physical barriers?	Where are the elevators in this station? Where is the cabstand? The bus stop?

either very satisfied or satisfied with the systems, while only 6% stated that they were not satisfied by the overall function of the systems.

- Infopolis 2 reported on a study that was carried out in France 6 months after the launch of the Digiplan device (*46*). The results provided included (*47*)
  - 50% of users of Digiplan used public transportation afterwards;
  - After consulting Digiplan, 3% of the users decided to use public transportation even though they had no definite intention of using it at the beginning; and
  - Similarly, after a first attempt at using the device (which was a "self-training" session), 8% of users took public transportation for a future trip, for which they again used the kiosk system.
- Customer satisfaction with TravInfo®—an ATIS providing information on traffic conditions and multimodal travel options to the public in the San Francisco Bay Area—was high (*48, 49*): 80% of users were repeat users of the service. Initially, during the field operation test, less than 1% of TravInfo callers asked to be rerouted to the transit menu after hearing about bad traffic conditions. After the field operational test, 5% were rerouted. Furthermore, 12.4% changed both departure time and route after making a call to Traveler Advisory Telephone System (TATS); 19.5% changed departure time; and 9.7% changed route only. High remarks were given to the system by 71.4% of users, while 41.9% thought that the system was better than radio or television.
- Surveys in Brussels show user satisfaction on Phoebus to be 90%. The systems are regarded as being very user-friendly, and display readability is felt to be excellent. The Brussels experience is that the use of public transportation on the lines equipped with these displays has increased by 6%.
- In Helsinki, 71% of the tram passengers and 83% of the bus passengers noticed the traveler information displays at their respective stops (*50*). The displays were regarded as useful by 66% of the tram passengers and 78% of the bus passengers. The most desirable features of the display were knowing the remaining wait time and knowing if the expected vehicle had already passed.
- In Glasgow, Bustime user feedback in surveys has been extremely positive. There is 98% acceptance, and 46% of users say that they would be encouraged to use the bus service more often because of the system (*51*).
- A survey that was carried out in 1997 and 1998 on the Timechecker system in Liverpool included the following results (*51*):
  - The Timechecker system led to a 5% increase in patronage on routes where Timechecker was installed;
  - 68% of passengers used Timechecker consistently;
  - The system claimed a 90% accuracy;
  - 85% of users believed that the use of Timechecker made waiting more acceptable; and
  - 87% felt that Timechecker gave a feeling of reassurance.

In an initial survey conducted about the Transit Tracker system, the results revealed the following (*52*):

- 73% reported that the bus was usually on time;
- 91% are satisfied or extremely satisfied with bus adherence to posted schedules;
- 97.3% feel secure while waiting at the bus stop during the day;
- 63.3% feel secure while waiting at the bus stop during the night; and
- 91% are satisfied or extremely satisfied with bus service.

Key findings from the aforementioned second survey of Transit Tracker users in Portland, Oregon (see Section 3.1.2) show that "passengers place a very high value on having Transit Tracker at their stop. Because of this, it is logical to assume that customer satisfaction will increase with the placement of more Transit Trackers throughout the system" (*53*).

Given the results of most of these surveys, which show that transit customers place a high value on TTI, particularly real-time information, one technique has been developed to predict "how customer satisfaction increases with the presence of the information system at bus stops and, in particular, with its performance" (*54*). This model could be used in the future to determine whether introducing real-time information at a transit stop or station would increase overall customer satisfaction with the transit service.

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infrastructure is considerably more developed than is transit's, and (as a result) passenger expectations are much higher. Nonetheless, it was found that transit riders to be interested in the same basic things as air passengers: information should be honest, timely, and accurate.

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SECTION **4**

STATE OF THE ART IN TTI

4.1 REVIEW OF TECHNOLOGIES

TTI systems are key technology applications within the transit industry, designed to provide timely and accurate information to help transit riders make decisions on modes of travel, routes, and travel times. This information generally includes transit service areas and routes; scheduled vehicle departure times; projected vehicle arrival times (through AVL); service disruptions and delays; information on fares, transfers, and other transportation services; and information on the various activities and events in the region. This information is used to assist customers and potential customers in making pre-trip and en route (including in-vehicle) trip decisions. Such a TTI system not only assists riders in their trip planning, but also improves the visibility of transit agencies within their communities. Often, access to this information is through various media, including the Internet, wireless PDAs, electronic displays at stops and stations, kiosks (at bus shelters, office buildings, shopping centers, and other locations), and land or mobile telephone.

Given that a basic level of information can be disseminated easily to the user via these media, the next level of information requested will be tailored to meet a particular user group's or individual's travel needs. This level of information may be provided by a private entity (sometimes known as an information service provider [ISP]).

Before describing the types of TTI and available technologies, it is important to note that underlying data of good quality is required in order for quality TTI to be generated. A comprehensive bus stop inventory is the most basic data required for applications that provide the basis for developing and disseminating information, such as an AVL system. Developing and maintaining this type of inventory is considered a challenge by many agencies for several reasons, including the fact that one agency may have several bus stop inventories that contain conflicting data on characteristics, such as exact latitude and longitude, and that resources necessary for maintaining such a database are scarce. In any case, an AVL system's accuracy and reliability is directly dependent on an accurate and reliable bus stop inventory, among other important factors, such as the accuracy of positioning technology.

4.1.1 Types of TTI

While there are any number of ways to categorize TTI—for example, based on the medium of communication used or the type of information that is received—the most common classification scheme is one that simply groups TTI services according to the stage of the journey at which the information is received. It has become an industry standard to classify TTI as being: (1) pre-trip; (2) en route (and in-terminal/wayside); or (#) in-vehicle.

One issue that must be addressed with all types of TTI is the accessibility of this information to individuals with disabilities. Technologies that provide accessibility of traveler information include DMSs at stops and stations for persons with hearing impairments (providing en route information); automatic annunciators and signage to provide in-vehicle information for persons with visual and hearing impairments, respectively; and talking signs and kiosks for passengers with visual impairments. Several transit agencies have deployed remote infrared signage systems (RISSs)—that is, hand-held devices that convert informational signs into a spoken message. RISSs provide persons who have visual impairments with significantly improved abilities to understand transit signage, navigate around a transit stop or station, and board a transit vehicle at a busy stop or station (*1*).

4.1.1.1 Pre-trip Transit Information

Pre-trip information is information that a rider accesses before embarking on his or her trip. It covers an array of areas such as route alignments, schedules, arrival times, delays, itinerary planning, and multimodal information. Hence, pre-trip transit information plays a critical role in the user's decision on which mode to take, what route(s) to take, when to make the trip, and how to get to his or her destination.

Pre-trip information includes static information on routes, schedules, fares, and system policies, and itinerary planning (also known as trip planning). This information includes timetables for individual train and bus routes and system maps and schematics. Information of this type, while updated periodically to reflect service changes, does not reflect the current operating conditions of the transit service. Historically, the main source of this type of information has been printed schedules, maps, and other materials displayed at rail stations, at bus terminals, and (often very sparingly) at bus stops. Pocket versions of these materials are distributed by many transit agencies either in the system or through local shops and other outlets. However, static information such as route, schedule, fare, and other information is now provided via the telephone, Internet websites, wireless media, and public kiosks. The systems needed to provide this information include automated telephone-answering systems, which allow passengers to access information on the route of their choice using the telephone keypad or speaking their responses; websites containing electronic versions of transit schedules and route maps; and computer kiosks with this information either preinstalled or available through an Internet connection. Providing static information using the Internet allows the user to select the specific type of information required, and, in some cases, this selection process can be more interactive than just selecting a specific schedule for a specific route. For example, the user may select a route by clicking on a specific place on a map of the transit system. He or she can then obtain the schedule associated with this route. Also, this selection process can be linked to real-time information about when the next few vehicles on that route are expected to arrive at specific stops or stations.

Improvements being made to static information include bus stop schedules that provide information about vehicles leaving from one specific stop and spider maps, which show all the transit services emanating from one specific stop. Transport for London has deployed these improved forms of static information for buses via its website (www.tfl.gov.uk/buses/). A detailed description of these improved forms of static information is provided in Section 8.

Itinerary planning allows passengers to plan a door-to-door (or station-to-station) trip using one or more transit services. This feature enables travelers who are making a one-time or atypical trip, for instance, to plan their transit journeys before leaving. Itinerary planning also allows tourists, visitors, and others who are less familiar with the transit services to plan complete routes to their destinations, reducing the stress of trying to navigate an unfamiliar transit system. Users can request a trip plan based on such variables as least travel time, minimal walking distance, lowest cost, least number of transfers, modal preference, and need for paratransit service.

Historically, most North American transit systems have provided itinerary-planning services by means of a telephone information service operated by knowledgeable staffers with (1) a good geographical knowledge of the system; (2) schedule and route information; and (3) in the most recent decades, software resources to interrogate a database rapidly and to find the itinerary or itineraries most responsive to the inquirer's constraints. Currently, the use of trip-planning software, which can calculate a number of alternative itineraries for each door-to-door or station-to-station trip, is quite common. The software can be accessed internally by agency staff and the information relayed to callers, or it may be made available to passengers directly through an automated telephone service, an Internet website, or a kiosk.

As mentioned in Section 3.1.2, many transit websites now provide itinerary planning. WMATA's RideGuide system is one such itinerary-planning service, which is provided on WMATA's website (www.wmata.com). This system, along with several others, will be described in detail in Section 4.2.

4.1.1.2 En Route (and In-Terminal/Wayside) Transit Information

The importance of providing transit information does not stop once the traveler embarks on his or her trip. Quite often and for various reasons, transit vehicles do not run according to the pre-trip information the traveler has received. En route travelers may experience anxiety if their vehicles do not arrive on time according to the schedule, if they are not sure where to go to catch their intended vehicles, or if they have missed the last vehicle (or do not know if they missed the last vehicle). Providing en route transit information plays a significant role in keeping travelers informed about the status of their vehicles; reducing their anxiety; and directing them to the right stops, platforms, and bays. Real-time or dynamic information describing current transit operations includes updates on delays, incidents, and service diversions along transit routes, as well as estimated vehicle arrival and departure times for stops along the routes. In contrast to static information, this dynamic information needs to be updated on a frequent basis if it is to be useful to passengers.

Real-time updates about transit operating conditions can be relayed to passengers in a number of ways. At transit stops and stations, DMSs, video monitors, and public address systems can report the estimated arrival (or departure) times of trains and buses and information about conditions or incidents that cause the buses or trains to operate in unscheduled ways. Updated information on vehicle arrival times and delays can also be placed on the agency's website or automated telephone answering system or on a cable television channel. An even more "interactive" system can send updates or alerts on transit operations to passengers via e-mail, pagers, portable phones, or PDAs.

In recent years, several transit agencies have deployed en route transit information systems. These real-time transit information systems are the subject of several current projects, including the aforementioned FTA and TCRP Synthesis projects. Information on these systems will be presented in detail in Section 4.2.

4.1.1.3 In-Vehicle Transit Information

In-vehicle transit information provides important information to travelers while they are en route. In-vehicle information such as automated annunciator systems help transit agencies comply with the Americans with Disabilities Act (ADA) by providing train stations and major bus stop locations in both text and audio formats. Furthermore, in-vehicle information reassures passengers that they have taken the right vehicle and route. Onboard displays are also used for informing passengers about transfer points, service disruptions, and other events.

Most transit operators that are implementing these systems are supplying some combination of audible and visual information on next stop, major intersection, and transfer points to achieve both objectives. Two primary media are used: automated audible annunciators and in-vehicle displays. Both can communicate location-related information to customers based on location data from the AVL system, data that is typically processed using an onboard microprocessor that is often used to support other onboard systems.

Another development in in-vehicle transit information is integrating bus destination signs with AVL systems to ensure that destination information displayed for waiting passengers is accurate. This integration is particularly important on multiroute corridors or multibranch routes and takes the responsibility away from the vehicle operator by automating destination sign changes with the AVL/computer-aided dispatch (CAD) system. Perhaps the most sophisticated examples of in-vehicle information involve transit agencies that are enhancing their fleet management systems so that passengers who are already on board can request and get confirmation on transfers to other transit services. This technology, called transfer connection protection (TCP), has been and is being deployed in several agencies in the United States.

4.1.2 Available Technologies

Static information on routes, schedules, and fares is typically provided via relatively low technology means such as printed timetables, information booths, and telephone systems. Augmenting this manually provided static information with real-time updates about transit service—for example, by giving bus locations or estimated arrival or departure times—requires specific technological infrastructure. These underlying technologies include AVL systems, communication systems, prediction algorithms, and media that disseminate TTI.

4.1.2.1 AVL Systems

Providing real-time information about transit vehicles (arrival and departure times, location, delays, etc.) requires that the location of the vehicle be determined. An AVL system is necessary for determining the location of vehicles, and, in some instances, it can also provide other operational parameters such as vehicle speed and direction. In addition to providing the data that is the basis for TTI, AVL systems are important from a safety and security perspective: dispatchers can respond more quickly to incidents, accidents, or other emergency situations because they know exactly where the vehicles are.

There are numerous types of AVL systems, each utilizing different technologies. Currently, the most common AVL technology is based on GPS. Other technologies include the signpost/odometer method and tag and tag-reader systems.

GPS-based AVL system: GPS is a series of satellites flying in geosynchronous orbit that emit signals that are received by vehicles equipped with GPS receivers to provide very accurate geographic location. By receiving signals from no less than three different satellites, the GPS receiver computes a vehicle's location by triangulation. GPS is often augmented by adding a transmitter tower of known geographic location (latitude and longitude): the GPS receiver and processor on a vehicle use the tower to provide error correction in case one of the three satellite signals is lost because of topography or urban canyons. This is called differential GPS (DGPS). Because selective availability—error that was introduced into the GPS system—is no longer used, DGPS may not be necessary. Further, the Nationwide DGPS System supported by U.S. DOT provides accuracy between 3 to 10 meters.

As mentioned earlier, GPS-based AVL systems are the most common of all AVL technologies. The Central Ohio Transit Authority's (COTA's) real-time bus arrival system (i.e., Ride Finder) uses such a system. In an effort to avoid duplicating equipment on board buses, COTA interfaced the Ride Finder interface with the newly acquired DGPS-based AVL system in order to obtain bus locations and other necessary data.

There are other examples of real-time information systems using GPS technology that are provided by a third party. A third-party company installs its GPS receivers on transit vehicles or it uses information from an existing AVL system. Some agencies that already have a GPS-based AVL system and do not choose to integrate it with the third-party's real-time information system end up with a second GPS receiver. Also, unlike other real-time information systems in which data processing is done at the agency's site on agency-owned computer equipment, a third-party system utilizes the third-party's servers at its own location. All data processing utilizing this type of third-party system is done at the third-party's servers. City-University-Energysaver (CUE)—a transit system in Fairfax, Virginia—has been using this type of system to provide its passengers with real-time arrival information at bus stops and on the web since 2001. Currently, at least seven other transit agencies are using this type of system.

Another interesting example is Virginia Railway Express's (VRE's) Train Brain system. Train Brain provides trains' locations on a system map on the Internet as well as information about major problems and delays. Although Train Brain utilizes GPS technology to determine the location of trains, the system is not entirely automated. Customer service agents receive train locations and then make the decision whether to report the delay of a particular train based on a certain threshold (10 min or later). This information is also used in a sister project called Train Talk, which provides e-mail alerts about VRE train status and delays or problems.

Signpost/odometer method: Using this AVL technology, information about a vehicle's location is determined by knowing the fixed location of a wayside signpost, when a vehicle passes this signpost, the current odometer reading, and the vehicle's scheduled route. Wayside equipment reads a tag/transponder placed on the vehicle as it passes by. A variation of this system is using loop-detectors rather than a tag reader to detect when a vehicle passes a certain point. Signposts are located at specific points along the route, and they transmit to a central point (usually dispatch) the identification (ID) of a vehicle that has passed by, or the vehicle's tag/transponder reads the ID of the signpost and transmits that ID back to a central point. Determining location between signposts is interpolated by using odometer readings. Upon receiving the data transmitted from either the signpost or vehicle, the central computer would compute the vehicle location by cross-referencing the data with the geocoded location of the signposts.

The Los Angeles County Metropolitan Transportation Authority (LACMTA) provides real-time arrival information on its Metro Rapid bus rapid transit system by using loop detectors throughout the route to determine bus location. The Los Angeles DOT (LADOT) developed this real-time system. As a Metro Rapid bus passes by one of the loop detectors, the bus number, time, date, and loop detector number are transmitted to the central computer using cellular digital packet data communications. The central computer looks at the time it took the last bus to traverse the same segment that the approaching bus is about to traverse. The approaching bus is assumed to take that much time to traverse that segment. The central computer will then transmit to the appropriate DMS the anticipated arrival time of the next bus.

Alternatively, in Seattle, Washington, King County Metro utilizes the signpost/odometer method to provide real-time arrival information. Signpost transmitters that broadcast a signal are distributed throughout King County. Buses pick up these signals and transmit them to the central computer, which in turn computes the buses's location. Transport for London also uses the signpost method for its vehicle location system.

One of the largest signpost-based AVL systems is used in London to monitor all buses in the London Buses division of Transport for London. The London Countdown system is based on this signpost (also called a beacon) AVL system. An onboard AVL unit receives the identity of a roadside beacon as the bus passes the beacon. Since each beacon has a unique identifier, the bus can then determine its location, and the location information is forwarded directly from the vehicle to a central system via the onboard radio. Currently, there are 5,000 beacons deployed in the London Buses service area. Figure 5 describes how the AVL and Countdown systems function.

WMATA's Metrorail system uses a fixed-block system, which could be considered another form of a "loop detector" method. Each block has a fixed running time. When a train passes by a certain block, the train information and block code are sent to the Rail Operations Computer System central computer. Using this information, the system calculates estimated arrival time at the downstream stations. The estimated arrival time, the line (which is designated by color and destination), and number of cars are sent to a group of signs at each station.

4.1.2.2 Communications System

The effective and efficient operation of transit systems depends on a sound and reliable communications system. Such a communications system also provides the necessary backbone for the operation of an AVL and other ITS systems (such as a real-time transit information system). The most common communication technology for transit ITS is wide-area wireless. Other technologies include dedicated short-range communications and local area networks (LANs).

There is considerable variation in the capabilities of each communication technology applied to transit. The technology can support voice communication, data communication, or both. Further, the technology can be one-way or two-way. Finally, the coverage of each technology is a critical factor.

Wide-area wireless: Wide-area wireless (WAW) networks are communication networks based on radio frequency technology. These networks are different from conventional, private, land mobile radio systems, which typically require larger and more powerful transmitters and towers.

There are two types of WAW systems: generic and proprietary systems. Generic technologies include services such as analog cellular, digital cellular, cellular digital packet data (CDPD), and personal communications systems. Proprietary technologies include the Advanced Radio Data Information Service (ARDIS™), EMBARC, MobileComm, Nextel, RAM Mobile Data, Ericsson, MTEL™, and others. European systems in particular may make use of protocols such as global systems for mobile communications, Radio Data System–Traffic Message Channel (RDS–TMC), digital audio broadcasting, and general packet radio service. CDPD has become an important data communications technology for transit because it supports relatively high data transfer rates (of up to 19.2 Kbps); it allows Internet protocol (IP) multicast (one-to-many) service—meaning that a base station can broadcast a message to many recipients simultaneously; and it utilizes unused space on existing cellular networks. However, CDPD often costs more than conventional communication technologies because charges are normally calculated based on the number of data packets sent per time period.

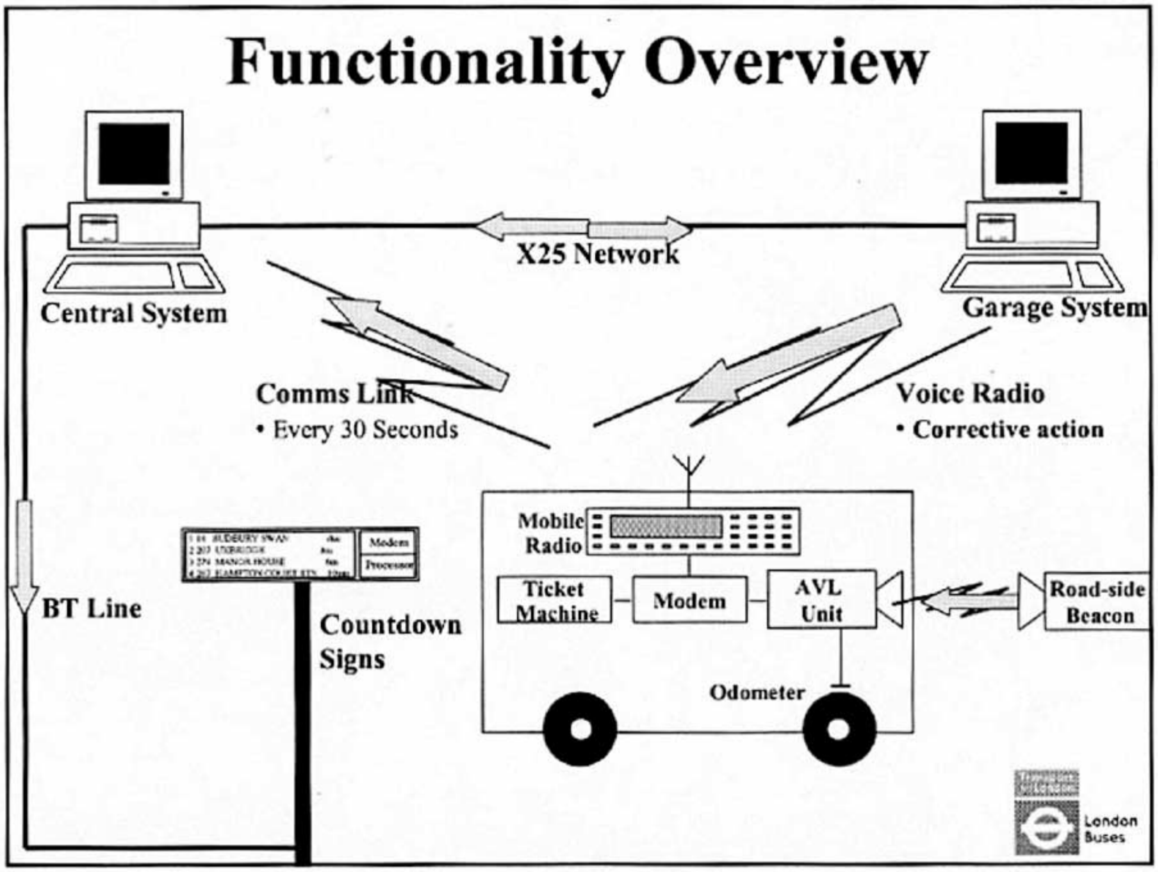


Figure 5. London Buses AVL and Countdown systems.

As mentioned earlier, LACMTA uses loop detectors to determine the location of its Metro Rapid vehicles. Using the bus number, time, date, and loop detector number received from the field, the central computer computes a bus's estimated arrival time. Once the estimated arrival time of the bus is computed, this information is transmitted to a display at bus shelters. The message travels from the LADOT's traffic-control center to AT&T's nationwide cellular data network, which relays it to a wireless CDPD/IP modem built into the electronic display at the target bus stop.

COTA's Ride Finder in Columbus also uses CDPD communications between the AVL central computer and DMSs at bus shelters. After the central computer computes the predicted arrival time of a bus, the information is sent to Verizon's cellular data network, which in turn sends it to a wireless cellular CDPD modem in the DMS. Each DMS has its own cellular subscription and messages are sent to a particular DMS.

Unlike COTA's Ride Finder, San Luis Obispo Transit wanted to lower the operational cost of communicating with the DMS units deployed at the bus stops. These units have a built-in intelligence module that allows all deployed signs to listen to a single, bundled text message sent by way of a pager. This one message contains the updated data for all signs at all stops. Each Smart Transit sign is easily programmed to know the bus stop(s) and bus route(s) it is servicing. Once the text message is received, the "smart" sign strips out and uses only the information meant for its specific location. The sign then uses this information to inform the waiting passengers of the time remaining until the bus arrives at that specific bus stop. This technique allows the transit agency to limit its Smart Transit sign communication link costs.

Dedicated short-range communications: Dedicated short-range communications (DSRC) have a somewhat limited application to transit. The most commonly used form of DSRC is the beacon/tag combination used for toll collection on bridges, tunnels, turnpikes, and parking facilities. The electronic tag, or transponder, contains a small radio transmitter that is used to emit a short-range radio signal that the beacon, or tag reader, receives. The beacon then transmits the data to the necessary computer hardware and software via radio frequency. The short-range radio signals are transmitted at a special frequency designated by the Federal Communications Commission for these short-range communication needs. The tags can be either active or passive. In Europe, DSRC are used for communications between transit in-vehicle equipment and roadside beacons to determine schedule adherence and to calculate the estimated time of arrival at the next stop (e.g., London Buses).

Tags and tag readers are also used in passenger rail systems for a variety of purposes. These purposes include automatic vehicle identification, tracking and control, and communications-based signal systems that can replace outmoded block-signal systems.

One agency that uses a short-range communications system is River Valley Transit (formerly CityBus) in Williamsport, Pennsylvania. Because bus bays were not preassigned for a particular route, buses had to select an available bus bay upon arriving at the transfer center. This arrangement made it a challenge for customers to find their buses. The solution to this challenge is a system that uses two variable text message signs to display the bay number for each bus as well as to warn when a bus is about to depart (see Figure 6). Each bus is equipped with a mobile data terminal (MDT), which the driver uses to send a message to the dispatch center indicating the selected bus bay. The mobile data communications use spread-spectrum antennas; bus antennas use unlicensed radio-frequency spectrum to communicate with transfer center antennas over a limited range on a "line-of-sight" basis. The original number of spread-spectrum antennas proved insufficient to communicate with the many different locations of buses around the transfer center (this short-range communications method requires a substantially clear line of sight), but this was addressed by adding antennas at various locations.

4.1.2.3 Prediction Algorithms

TTI systems that provide arrival and departure time predictions depend on a prediction model or algorithm to process vehicle-location and related information. The accuracy of the predicted arrival time is contingent on the accuracy of the model or algorithm being used. A variety of data is used as input to the prediction models or algorithms. These inputs typically include vehicle identification, vehicle location, cur-

Figure 6. CityBus Transit Transit Center sign.

rent traffic conditions, historical traffic conditions, and real-time operating data from the last several buses on that route that passed that stop.

LACMTA's Metro Rapid real-time information system contains a prediction model that was developed by LADOT. The model operates by recording bus arrival time at every bus detector, then estimates bus travel time using previous bus information, and finally calculates arrival times for approaching buses to all bus stops (*2*):

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

The King County Metro bus arrival information system (MyBus) employs an algorithm that uses time and location pairs with historical statistics in an optimal filtering framework to generate estimated arrival times. The algorithm relies on assumptions that "allow the problem to be formulated in a statistical framework and fulfill the requirements necessary to use the Kalman filter to make optimal estimates of the predicted time until arrival for individual vehicles" (*3*). A set of mathematical equations, the Kalman filter provides an efficient computational (i.e., recursive) solution of the least-squares method. The Kalman filter is powerful: it supports estimations of past, present, and future states, and it can do so even when the precise nature of the modeled system is not known (*4*).

4.1.2.4 Information Dissemination Media

AVL, communications, and other key underlying technologies are necessary systems to collect and process the data that is used in TTI systems. However, these systems are not very useful without a dissemination mechanism to communicate the TTI to travelers. Not long ago and aside from printed media, traveler information was accessible only by telephone. The technological advances that have taken place in communications in the past few years have greatly impacted how TTI is distributed to users. Currently, transit agencies are using a variety of media to better inform their riders about their services. These media include mobile phones, pagers, PDAs, DMSs, video monitors, kiosks, and the Internet.

Not only did the advances in communications impact how the information reaches the users, but it also revolutionized when the user can access the information and the type of information that is available. Wireless communications make it possible for travelers to receive information anywhere and anytime through wireless devices such as PDAs, WAP-enabled cell phones, and DMSs at stops and stations. The introduction of the Internet and kiosks for providing detailed traveler information, customized itineraries, interactive maps, and real-time information allows users to access TTI on their personal computers and at key activity centers.

Information dissemination media can be divided into four categories: personal communication devices, noninteractive displays, interactive wayside devices, and the Internet and e-mail services.

Personal communication devices: This category includes traditional land-line phone and wireless devices such as cellular phones, pagers, and PDAs. Wireless communications devices are becoming more and more popular with transit agencies because they provide a better level of customer service at a very low cost. Wireless devices are not limited to accessing real-time information: they are also being used to provide static schedule information. For example, ZeroSixty, which will be described in Section 6, provides transit schedules that can be downloaded to a subscriber's PDA. Another example is using a WAP-enabled cell phone to receive an itinerary from Transport for London's Journey Planner.

Noninteractive displays: These devices can be divided into DMSs at bus stops and train stations, DMSs on board vehicles (automated annunciation system signage), and video monitors. DMSs are more popular than are video monitors because DMSs come in a variety of shapes and sizes and are more versatile. Video monitors and wayside DMSs are mainly used to display arrival times, bay information, and service delays; onboard DMSs are mainly used for announcing and displaying next stop information.

Interactive wayside devices: An example of an interactive wayside device is a kiosk. Kiosks are being deployed at major bus centers, train stations, and other public places such as hotels, airports, and commercial centers. The single most important advantage of kiosks is that they are interactive devices. This feature allows the users to access the information they need in a relatively short time. Moreover, kiosks can provide an infinite amount of information when they are connected to the Internet by providing links to a host of sites such as sites on weather, traffic, and other local information.

Internet and e-mail services: Through the Internet, users can access a variety of TTI at any time to obtain schedules, real-time arrival information, itineraries, and other TTI. E-mail services, on the other hand, are usually limited to information on delays, incidents, emergencies, or real-time arrival information. Furthermore, unlike the Internet, e-mails are not interactive and are one-way messages. Given the importance of the Internet in providing TTI, the current state of TTI deployment on the web is reviewed as follows.

The Transitweb website (transitweb.volpe.dot.gov/introduction.asp) provides comprehensive information on transit websites that were reviewed in July and August 2001. A total of 637 websites were reviewed, with 520 from urban areas and 117 from rural areas. This review examined the frequency of specific website features, as shown in Table 7.

The Transitweb review conclusions included the following (*5*):

- There is wide variation across websites in content and presentation of information. This variation is present within groups of websites from similar rural or urban areas or within groups that are eligible for the same category of federal funds.
- The most common features are fare and schedule information, but they are not universally present. Since this information is essential to using a transit system, it seems that significant improvements could be made by adding the information to the sites that lack it. There was no significant change between last year and this year in the percentage of agencies with fare and schedule information.
- The main area of improvement in the past year is for route-choosing content. System maps have been improved so that more show transfer points clearly. Itin-

TABLE 7 Frequency of specific website features

FEATURE	PERCENTAGE OF WEBSITES WITH FEATURE
Route-choosing content:	
Any system map	44.0
With clear transfer points	27.9
With point-and-click	15.9
With "you are here"	.05
With itinerary planner	7.6
Route-specific information:	
Route maps	49.7
Schedules	81.0
Fares:	
Comprehensive information	88.4
Online purchase of fare media	6.7
List of purchase locations	43.0
Multimodal information:	
Traffic information (real-time or construction notices)	1.1
Park-and-ride lots	15.0
Bicycles	29.0
Information for tourists (highlighting common tourist destinations on maps, etc.)	10.8
Links to websites with related content:	
Other transit	41.0
Traffic	7.4
Intercity public transportation (bus, train, air)	21.5
Government	28.4
Current news, service updates, or real-time information:	
Current info (temporary re-routing notices, special events, etc.)	21.5
Real-time info (transit vehicle locations, incident information, parking availability, etc.)	1.9
Sign up for e-mail or other alerts	4.7
Rules and restrictions	52.0
Contact information (e-mail/telephone)	76.2/89.6
Website	24.5/.08
Transit	21.1/36.9
Unspecified/general/multiple	29.9/51.5

erary planners are still rare, but are becoming more common.

- A fair number of transit websites have links to other sites (although they are not necessarily the complete set of sites that users may find helpful) or to a comprehensive set of websites providing information on all modes of transportation available in the area. The links frequently include sites that are irrelevant and sometimes imply transportation options that are not available.
- The most common type of information on other modes of transportation is information about the use of bicycles in conjunction with transit. Information that might facilitate a decision about whether to drive or take transit—such as traffic conditions, links to traffic sites, or information on park-and-ride lots—is rare.

4.2 CURRENT EXAMPLES OF DEPLOYMENT

In this section, key examples of deployed TTI systems are presented. These examples can be distinguished from the information presented in Section 5 in that these examples briefly illustrate the use of the technologies described in Section 4.1. The systems described in Section 5 do not necessarily focus on the technological aspects, but provide an overview of key TTI systems throughout the world.

It is important to note that providing traveler information is not the only reason (and in many cases, is not even the main reason) why transit systems deploy the various ITS technologies. Equipping vehicles with AVL and communication technology and monitoring vehicle locations typically are driven more by operational efficiency and concerns of public safety and security. For example, knowing where the buses are at any point in time and being able to communicate with them permits operational policies that can improve the general level of service to passengers under both routine and extraordinary circumstances. Prior to using these technologies, many transit systems would use road supervisors to make decisions about, for example, taking a bus out of service mid-route and turning it to operate in the opposite direction or on another route. Such decisions would typically also have to be made with very imperfect information about the locations of other relevant buses.

The business case for investing in these technologies is most often made on grounds other than to provide TTI, not because that is not considered an important product of the underlying technologies, but because the returns on improved TTI may be far less tangible and quantifiable than the cost savings and benefits from an operational viewpoint. In this sense, the additional investment to make AVL-derived information available to the traveling public may well have a relatively low cost, viewed in terms of both the total infrastructure investment and the incremental cost per ride. However, not all AVL systems are capable of generating continuous, real-time data that can be used for passenger information purposes.

It is also worth noting that the technologies summarized in Section 4.1 are not the only components of current initiatives to add enhanced monitoring and communications capabilities to transit vehicles and stops. Security and safety concerns are leading to, for instance, greater use of technologies such as closed-circuit television systems at stops or in stations or terminals and video cameras and audio recording devices on board vehicles. The deployment of these technologies may have limited benefits in providing information to passengers. The urban transit analog of the traffic website offering real-time camera images of highway conditions might, for example, include images of the current level of crowding on subway platforms.

4.2.1 Pre-Trip Information

WMATA's RideGuide system provides pre-trip itinerary planning on the Internet and by telephone (using interactive voice response technology). Users are prompted to enter the origin and destination of their trip (see Figure 7). Next, they enter a time when they plan on making the trip. They then select whether they want to minimize time, walking, or number of transfers and whether they want to travel by rail only, bus only, or by both (see Figure 8). Once all this information is entered, the system provides not one itinerary, but multiple itineraries, giving the user a number of alternatives from which to choose (see Figures 9 and 10). Itineraries also include walking directions and fare information (see Figure 11).

Ventura County Transportation Commission (VCTC) is another agency that provides an itinerary-planning application. Similar to WMATA's application, VCTC's application accepts addresses as well as landmarks for origin and destination. Users also select the time of their trip, type of fare they will be using, special accommodations, and mode of travel. The resulting itinerary not only provides the users with exact directions and fare information, but also displays the direction of travel in a map format, making it easy to understand how to get to the intended destination. Another significant feature of this particular application is that it encompasses various modes of travel such as buses, ferries, and trains (including AMTRAK).

VRE is another transit agency that provides pre-trip transit information to its customers. VRE is a commuter rail service operated along two lines (Manassas and Fredericksburg) from the Virginia suburbs to downtown Washington, D.C. VRE offers two real-time transit information innovations—Train Brain and Train Talk. Train Brain, implemented in 1999, is a schedule-based JAVA Applet program that displays the location of VRE trains on a map on the VRE website. The Train Brain webpage on the VRE website displays the trains operating according to schedule. The display is periodically updated with information about delays from the Communications Center, which derives the information from the GPS-based AVL system or from the train conductor. The

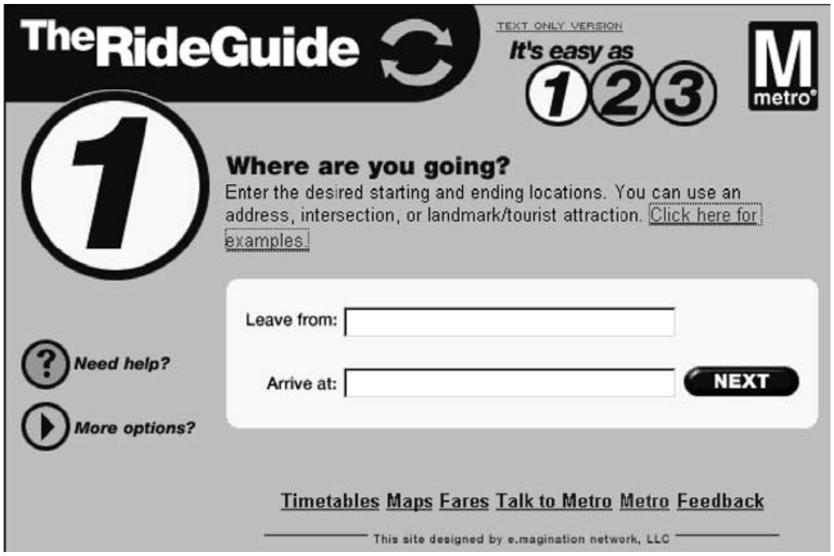


Figure 7. RideGuide origin and destination entry screen.

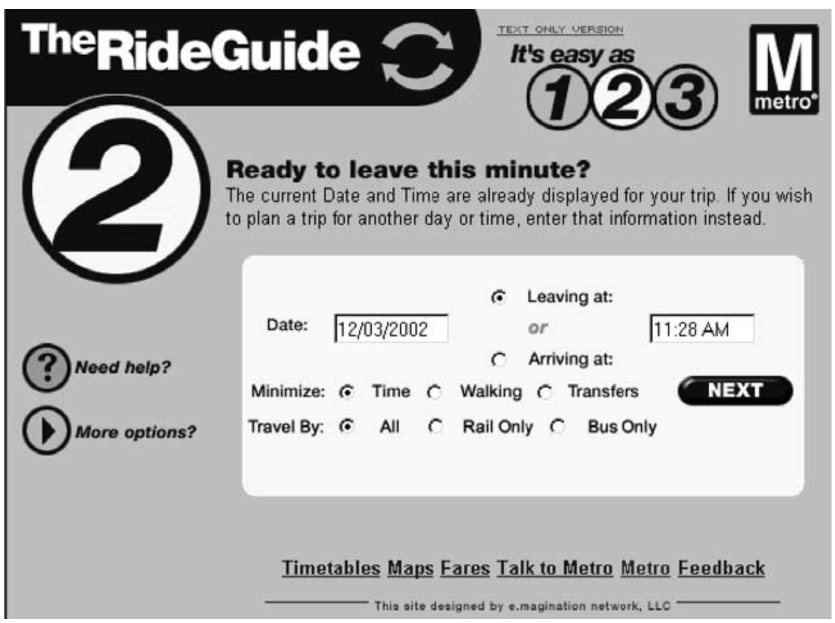


Figure 8. RideGuide entry screen for other parameters.

system is not fully automated as Train Brain only shows the delays that Customer Service decides to reveal.

Train Talk, on the other hand, provides e-mail alerts about VRE train status to riders who register for this service. As of December 2002, 6,500 passengers were registered on the Train Talk e-mail list (out of daily ridership of 12,000 to 14,000 one-way trips). Train Talk is not route- or station-specific, that is, the same e-mails are sent to all Train Talk customers. Train Talk information largely reports significant service disruptions, potential disruptions, and potential equipment changes.

Denver's Regional Transportation District's (RTD's) Bus Locator, implemented in 1999, is an Internet application that provides the ETA for the next two to three bus/rail arrival times based on the route and direction selected (see Figure 12). When real-time data is not available, the Internet application displays scheduled arrival times instead. Another real-time application being used at RTD is Talk-n-Ride. This system

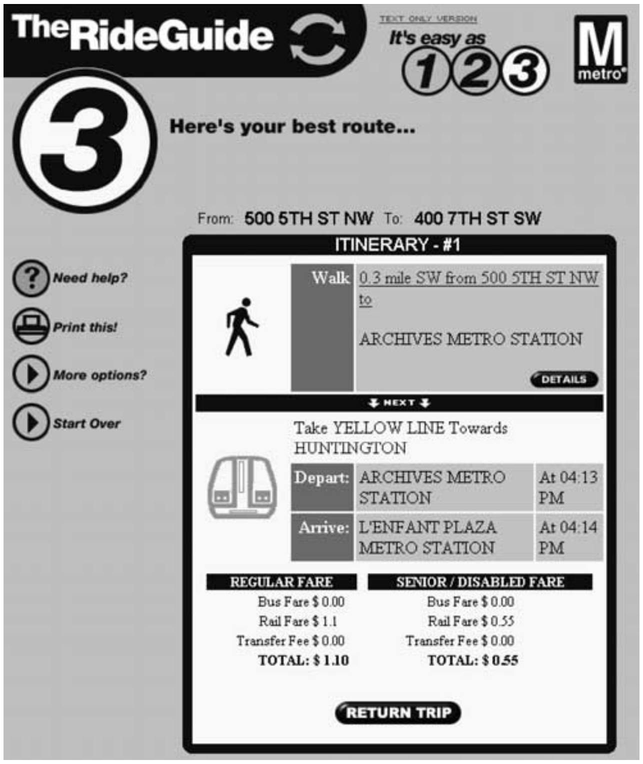


Figure 9. RideGuide first itinerary alternative.

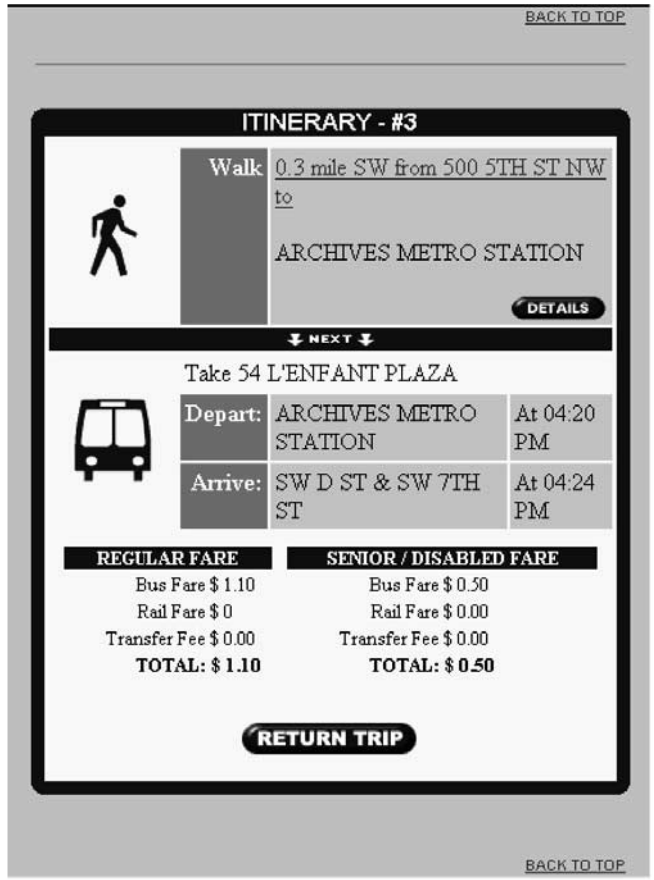


Figure 10. RideGuide third itinerary alternative.

is an interactive voice response (IVR) system that provides real-time "next bus/rail" arrival information for RTD buses and light-rail routes and stops. The user has the option to enter basic information on route and direction and then the option to choose real-time or scheduled time. The resulting information is then presented for arrival times for the next three buses/light-rail vehicles. The basic technology used for this system is a text-to-speech system, in which schedules in Extensible Markup Language (XML) format are translated into voice schedules. The real-time information is taken from the same server that is used to provide arrival information for the Internet application. A more detailed description of Denver's TTI Systems is presented in Section 5.

Portland Tri-Met's Transit Tracker real-time transit information system (next bus and train arrival) is presented to users through two types of media: the Internet and light-emitting diode (LED) signs at the stations and bus shelters. The Internet application (www.tri-met.org/transittracker/index.htm) currently provides information on all TriMet's bus stops (8,000 bus stops). This system allows the user to choose a route, the direction, and a specific bus stop and then provides the user with the next few bus arrivals in a countdown fashion (see Figure 13). The user has the option to view more arrivals for different bus routes and stops.

In Seattle, BusView and MyBus are two additional applications that help King County Metro's users make travel decisions before they start their trip. BusView is an Internet application that provides information on the location of the King County Metro buses by tracking them and displaying their real-time location on a map (see Figure 14). Bus progress along a specific route is shown in the progress window, which can be viewed by clicking on a particular bus and choosing the progress view (see Figure 15). The real-time vehicle location is provided by Metro's signpost-based AVL system. The map is updated every 1 to 3 minutes. One relatively new feature in BusView is an "alarm feature." A user can set an alarm to have BusView alert him or her when it is time to leave to catch the bus. The user chooses a specific time point (designated points along a route) and sets an alarm. When the bus reaches that point, a message is sent to the user alerting him or her that the bus has reached the requested destination.

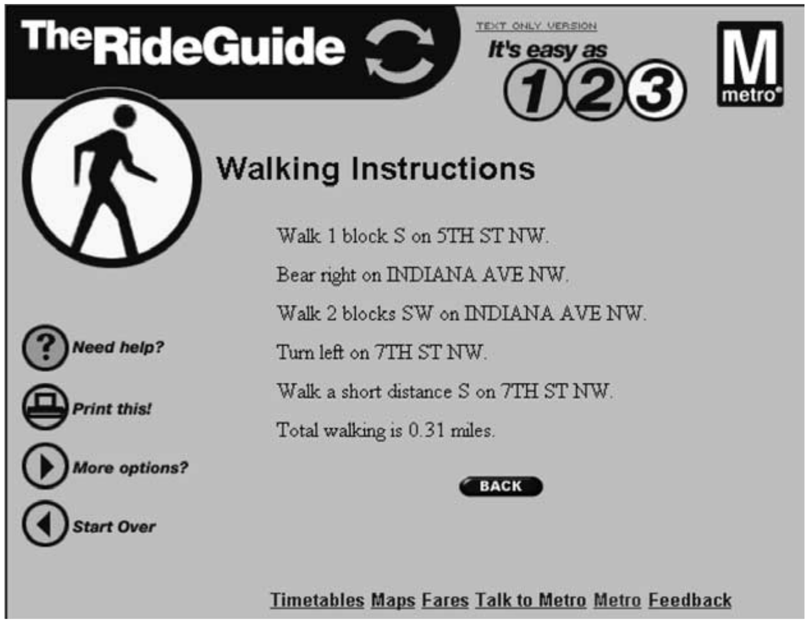
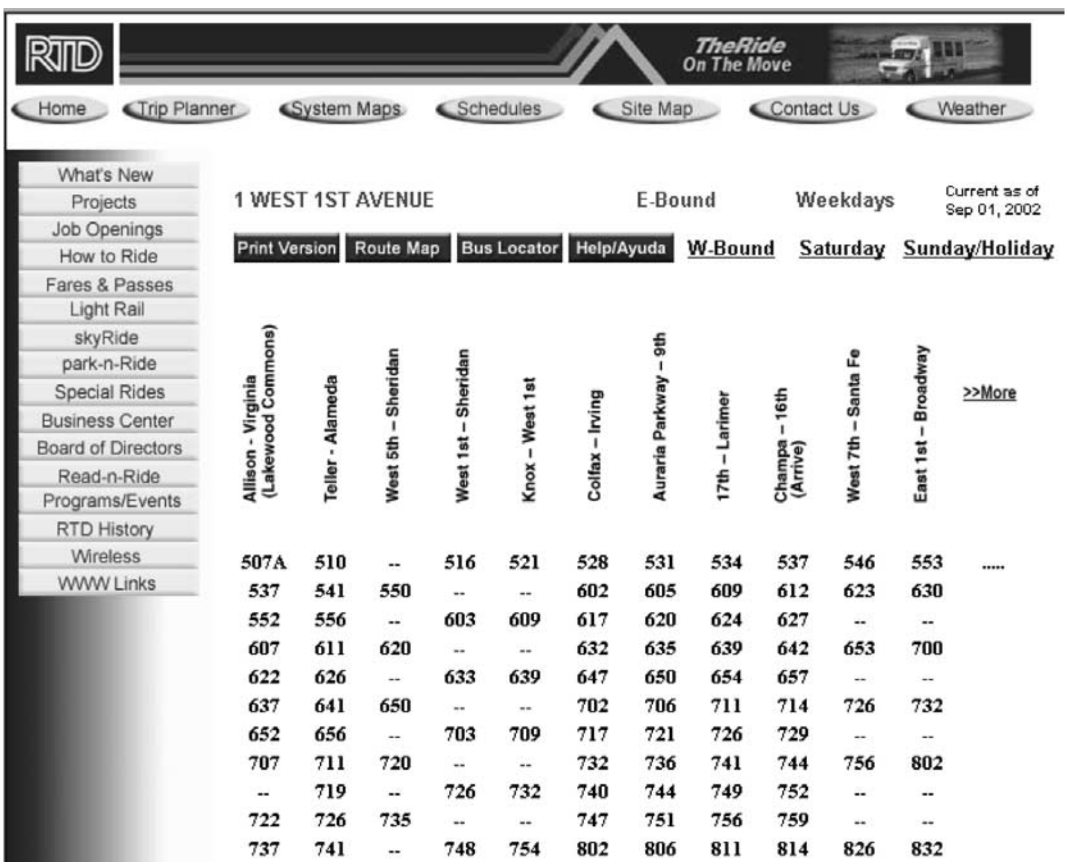


Figure 11. RideGuide walking instructions.



Allison - Virginia (Lakewood Commons)	Teller - Alameda	West 5th – Sheridan	West 1st – Sheridan	Knox – West 1st	Colfax – Irving	Auraria Parkway – 9th	17th – Larimer	Champa – 16th (Arrive)	West 7th – Santa Fe	East 1st – Broadway	>>More
507A	510	--	516	521	528	531	534	537	546	553	.....
537	541	550	--	--	602	605	609	612	623	630	
552	556	--	603	609	617	620	624	627	--	--	
607	611	620	--	--	632	635	639	642	653	700	
622	626	--	633	639	647	650	654	657	--	--	
637	641	650	--	--	702	706	711	714	726	732	
652	656	--	703	709	717	721	726	729	--	--	
707	711	720	--	--	732	736	741	744	756	802	
--	719	--	726	732	740	744	749	752	--	--	
722	726	735	--	--	747	751	756	759	--	--	
737	741	--	748	754	802	806	811	814	826	832	

Figure 12. RTD's schedule page, with bus locator option.

Figure 13. Tri-Met Transit Tracker on the Internet.

A different King County Metro Internet and wireless application provides detail on the real-time bus arrival of Metro buses. This information is presented in a tabular form, and it uses the data from the AVL system along with a prediction algorithm to determine the time when the next bus will arrive at a particular stop. Historical operational data is also used by the prediction algorithm to predict the arrival times. MyBus also provides status information on each bus (i.e., departed, 10-minute delay, etc.).

Another agency that provides pre-trip traveler information is Washington State Ferries (WSF). This real-time Internet application (www.wsdot.wa.gov/ferries/), called Vessel Watch, provides the location of the WSF vessels by displaying their real-time location on a map (see Figure 16). The vessels are represented as colored arrows (directional) on the map when they are moving and as colored circles when they are stopped. The vessel locations are shown based on the route selected from a drop-down menu. The route names are also represented on the map alongside the moving arrows. The Vessel Watch information is updated every 3 minutes. The Internet application was developed in-house with help from contractors from Washington State DOT.

4.2.2 En Route Transit Information

The real-time transit information system implemented by San Francisco Municipal Railway (MUNI) in 1998 started as a demonstration project by a private provider. The private provider demonstrated the capability to provide real-time next train arrival information using AVL data from MUNI trains in 1996 on LED signs installed at train station platforms (see Figure 17). The demonstration turned into a pilot in 1998, and MUNI implemented this system for the whole rail fleet by 1999. The system includes signs on the station platform that provide next train arrival information for the next 2 or 3 lines. An audio component was added to this system by another vendor.

Using the same real-time data that is provided via Bus Locator and Talk-n-Ride, Denver RTD implemented an application to provide real-time next arrival information to

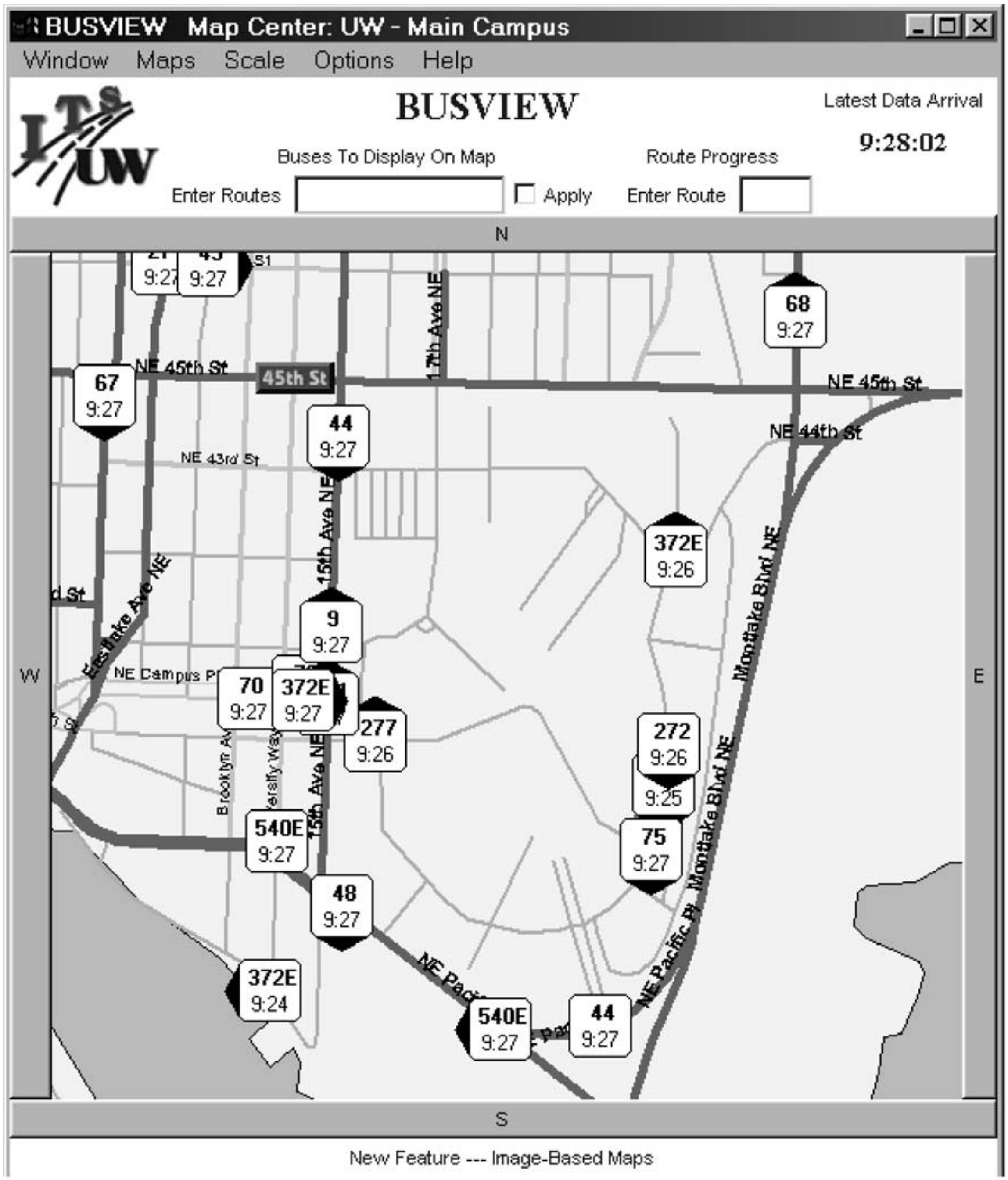


Figure 14. BusView main window.

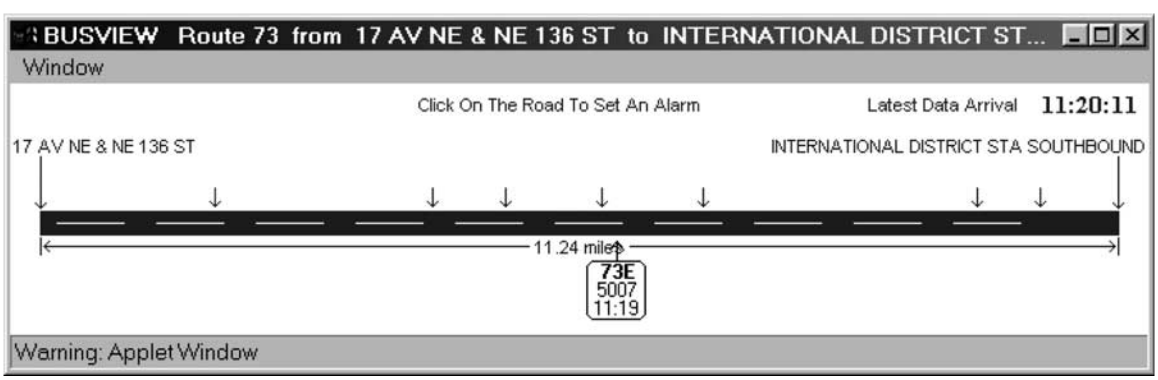


Figure 15. BusView progress window.

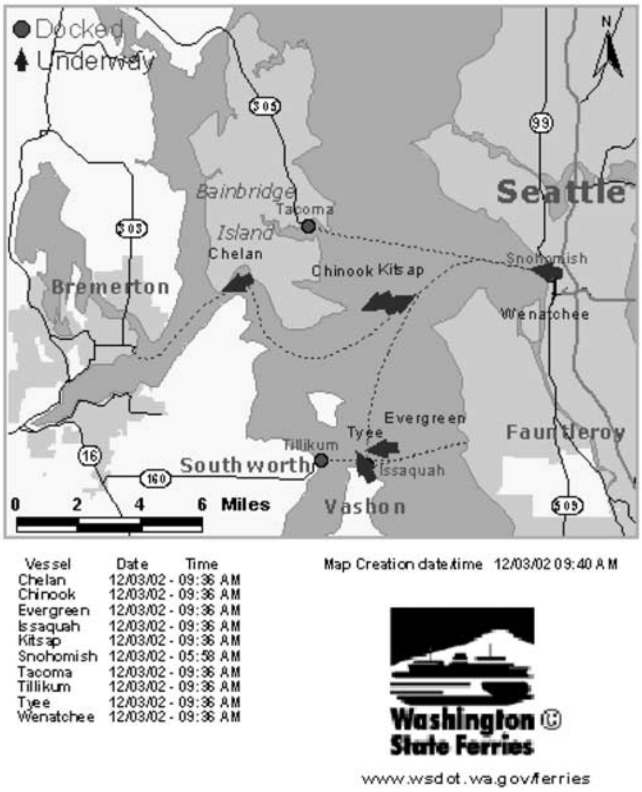


Figure 16. WSF Vessel Watch for Seattle-Bainbridge Island route.

wireless devices, including PDAs and WAP phones. This application is called Mobile-n-Ride (www.gortd.com). Once the user connects to the Internet web page via mobile device, he or she enters a route number, a direction, and a stop. When all the parameters are entered, a message containing the ETA for the next two to three vehicles is sent to the mobile device using the same operating system as the device that requested the information.

In Pompano Beach, Florida, when the double-tracking work was first being planned, Tri-County Commuter Rail was concerned about the varying train delays that would be caused by the construction and the impact these disruptions might have on its ridership. Hence, it deployed a real-time arrival system in 1996 to address this potential problem. The system provides real-time information on arrival times of trains, location of trains, and service delays and disruptions. LED DMSs display arrival times of the next train in a countdown fashion (e.g. “Train in *X* Minutes”). Messages at train stations are also provided in audio format to accommodate passengers with visual impairments. Audio messages are automatically played whenever text messages are updated.

As part of its long-range plan, COTA in Columbus, Ohio, implemented a real-time bus arrival system in August 2001 called RideFinder. The initial demonstration was conducted on the Downtown Link and the Hotel/Airport circulator routes. The purpose of this system is to provide COTA’s customers, at certain bus stops and hotel lobbies, with the actual arrival time of the next bus. The arrival time for the Down-

Figure 17. San Francisco MUNI shelter with LED sign.

town Link is displayed on DMSs. The signs display the route number, estimated arrival time, time, and date. The Hotel/Airport circulator uses touchscreen interactive kiosks for displaying the information (see Figure 18). The kiosks display a map of the route with the actual location of the buses as well as the estimated arrival time of the bus at that stop (see Figure 19). The user can also access weather information and information on COTA's service and fares at the kiosk. In addition, arrival time is provided in audio format. Users with visual impairments can push a button on the kiosk to hear the estimated arrival time of the following bus.

In an effort to provide better service to its customers, WMATA introduced a real-time passenger information display system (PIDS), which provides actual arrival times of trains, elevator and escalator outages, incident information, and security alerts. DMSs at Metrorail stations display arrival times of the Metro trains in a countdown fashion, as shown in Figure 20. The DMSs are also used to provide information during an emergency or terrorist situation. Time is also displayed on the DMSs when the ETA information is not being displayed. WMATA uses the DMSs to disseminate events messages, especially on weekends when there is more time between trains and therefore greater opportunity for other messages to be displayed.

Customers of River Valley Transit (formerly CityBus) in Williamsport, Pennsylvania, faced a dilemma as to how to inform passengers at their Transit Center about how to locate their buses (i.e., which bus bay had which bus). Incoming buses must select an available bus bay upon entering the facility, making finding the right bus a challenge for passengers. The implementation of a unique information system was needed to inform customers about the location of their bus. The system, deployed in 2000, uses two variable text message signs to display the bay number for each bus as well as to warn when a bus is about to depart (see Figure 6). Each of these variable signs has 10 rows of 2-in.-high characters. Each row is labeled for 1 of the 10 different bus bays and indicates the route name for any bus currently occupying that bay. There is also a public address system that provides audible announcements for the sign messages.

Figure 18. RideFinder kiosk.

San Luis Obispo Transit (SLO Transit) in San Luis Obispo, California, provides another example of a real-time bus arrival system. In 2001, SLO Transit completed the installation of Efficient Development of Advanced Public Transportation Systems (EDAPTS) prototype ITS equipment on its buses and at bus stops to test the operational suitability of ITS technology in a small transit agency environment. The EDAPTS concept and the prototype equipment were designed and developed by California Polytechnic State University researchers and undergraduate engineering students under a research contract funded by the California DOT's (Caltrans's) Division of New Technology and Research and by FTA. EDAPTS is designed for small and rural public transportation agencies and focuses on providing basic functionality that is affordable for small agencies and that can be expanded. EDAPTS was developed with special attention given to providing low, post-deployment operating and maintenance costs. The current system provides real-time information on arrival times of buses, location of buses, and service delays and disruptions. DMSs at selected bus stops display arrival times of the next bus in a countdown fashion (e.g., "Route 34 Here in *X* Minutes") (see Figure 21). Vehicle locations are available only on the dispatchers' monitors because the DMSs do not have the capability to display graphics. The electronic signs are in compliance with the ADA as they have 3-in.-high characters; however, there are no audio announcements available.

Portland's Tri-Met installed Transit Tracker LED DMSs at several bus stops with shelters and light rail (Metropolitan Area Express [MAX]) station stops to provide real-time arrival information to its customers. Tri-Met is in the process of installing more signs (scheduled to install 50 by 2003) and has planned to install a total of 250. The LED signs at the MAX stations currently display "next scheduled arrival time" and not the "next train arrival." In the bus shelters, the LED signs display the real-time next bus arrival in a countdown fashion. In one transit mall area where there is more than one bus and one route served, there is a multiline LED DMS, which shows the route number, direction, and countdown time for three or four buses (see Figure 22).

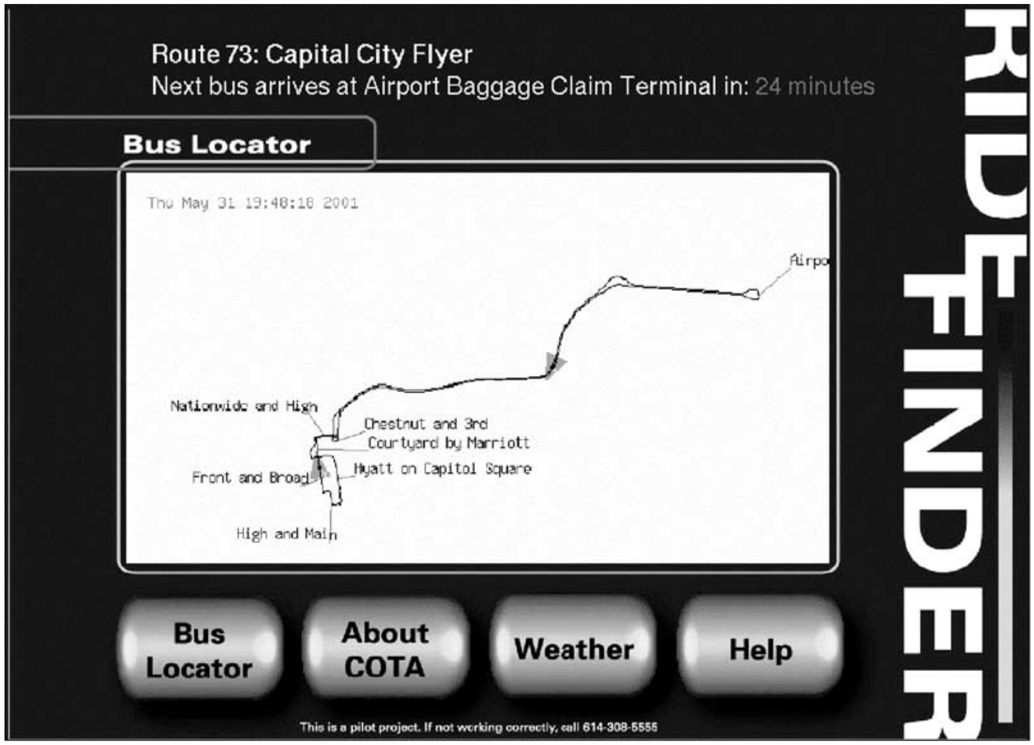


Figure 19. RideFinder real-time bus location screen.

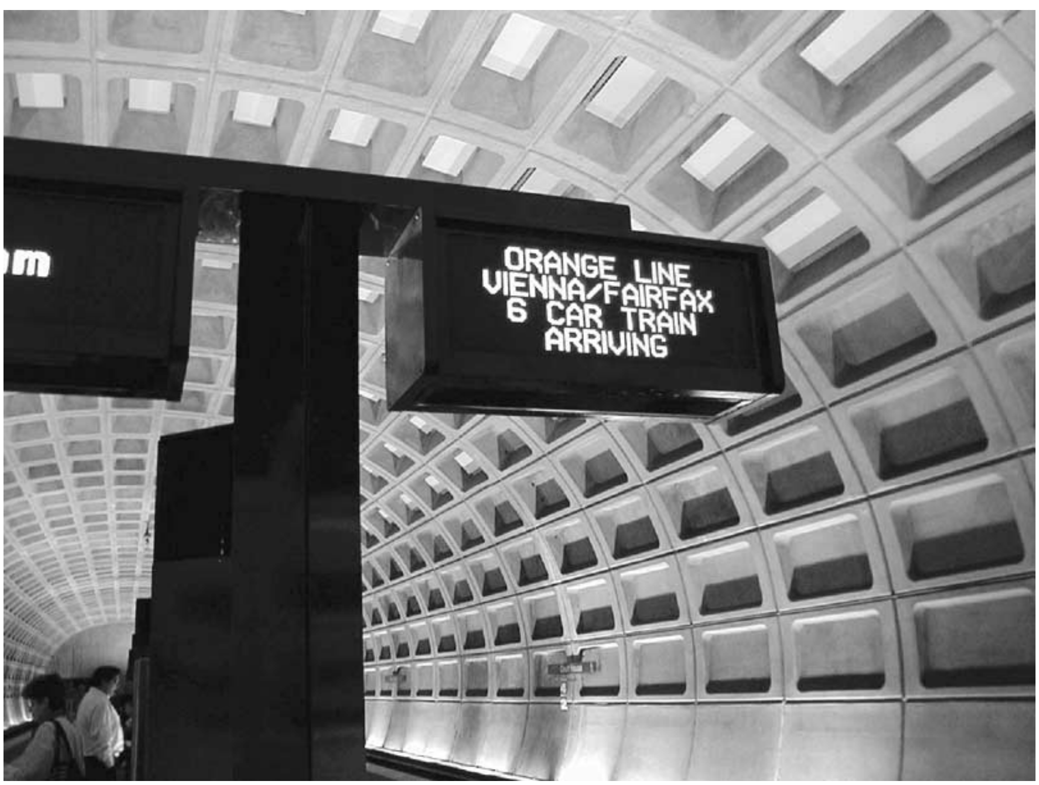


Figure 20. WMATA's passenger information display system.

Figure 21. SLO Transit smart transit sign.

4.2.3 In-Vehicle Transit Information

An example of an automated annunciation system providing displays that are more sophisticated than the typical display on in-vehicle electronic LED signs is the system implemented on one long-distance, limited-stop bus route in Orlando, Florida, called Lynx. This system provides the following information on multiple high-resolution video screens in the bus: (1) real-time activity information, including route information, time, and date; (2) next-stop announcement and display; (3) public service announcements; (4) scrolling headlines and text advertising; and (5) actual video (e.g., short films, newscasts). See Figure 23 for a photo of this onboard annunciation system.

Figure 22. Portland Tri-Met Transit Tracker multiline DMS.

Figure 23. Automated annunciation system on board Lynx bus.

4.3 REFERENCES AND ENDNOTES FOR SECTION 4

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SECTION 5

TTI SYSTEMS

This section identifies and describes specific TTI systems in North America and Europe. These systems are presented in this section to provide comprehensive examples of successful TTI deployments around the world. Many of these systems do not just provide one type of TTI (e.g., pre-trip vs. en-route)—they provide a multifaceted approach to providing TTI. Please note that some of the systems described in this section may have been mentioned briefly in Section 4.2. The reason for including them here is to provide more detail than what was previously presented.

Also, it is important to note that in-depth case studies of several of these systems was conducted as part of TCRP Project J-09, Task 4, the results of which were published as *TCRP Report 84, Volume 4* (*1*). Each case study presents the following information:

- System design and functionality for each website feature,
- Project objectives,
- Implementation issues,
- Outcomes/benefits, and
- Planned improvements.

5.1 NORTH AMERICAN SYSTEMS

Table 8 summarizes the North American TTI systems that are presented in this subsection.

5.1.1 Cape Cod Regional Transit Authority

In Dennis, Massachusetts, the Cape Cod Regional Transit Authority (CCRTA) system is an Internet application (www.thebreeze.info) that provides information on the location of CCRTA buses by tracking and displaying the vehicles' real-time locations on a map. The real-time vehicle location is collected from the GPS-based AVL system. All collected data is processed by the operations center as part of the CAD/AVL system. The locations of the buses are then displayed on a service map on the Internet. As shown in Figure 24, the buses are represented as (directional) arrows on the map and as circles when they are stopped. The bus routes are represented by thick, colored lines. To get information on any of the icons on the map, there is an "Info" button that users can select, and a pop-up screen provides detail on the routes and the stops.

There is an option to select and zoom in or out of an area based on the locale that a user is interested in. The user can choose to view a specific area of the map by entering addresses or common names for an origin and destination. Once the selection is made and "Return to Map" is clicked, the map will automatically zoom in on a $1\frac{1}{2}$-mile area surrounding the chosen points of interest. The page (map overview) is automatically refreshed every 90 seconds. Currently, the Internet application provides bus location information as well as information on routes and stops. The RTA is planning to add LED DMSs at the Main Bus Terminal and eventually at bus shelters.

5.1.2 LACMTA/LADOT

In Los Angeles County in 2000, LACMTA deployed a new bus rapid transit system, called Metro Rapid, to make riding the bus more attractive to the traveling public. The new service uses the city's computerized Automatic Traffic Surveillance and Control System (ATSCS) to provide signal priority for these buses. As part of the signal priority system, LADOT developed a passenger information system that uses wireless electronic displays at its Metro Rapid bus shelters to provide real-time arrival information to the rider. Currently, real-time information is available at stops along both Metro Rapid lines. The one-line LED DMSs in specially designed bus shelters are mounted 9 feet above pavement level and display a next bus arrival message in 2-in. bright red characters (see Figure 25). DMSs are also used to display delay messages whenever a bus is running 3 or more minutes late. In this case, the DMS will display "Next Bus Delayed."

Every morning, LACMTA provides the LADOT command center staff with the schedule for each Metro Rapid bus that day. A transponder mounted on the chassis of each bus is used to track the bus's progress along its route via loop detectors installed in the roadway at each intersection. Throughout the day, the ATSCS computer compares that schedule with the actual location of each bus. If the bus falls behind schedule, the computer can extend the green light at the traffic signal in the bus's immediate path so that the bus can get back on schedule. Since the computer knows the location and speed of the bus—and the fact that lights in its path will remain green—the computer can accurately calculate the time that the bus will take to reach its next stop. This information is transmitted to downstream stops. The message travels from the ATSCS center to AT&T's nationwide cellular data network, which then

TABLE 8 Summary of North American cases

Location or Agency	Description
Cape Cod RTA, Dennis, MA	Internet application provides information on the location of the Cape Cod RTA buses by displaying the vehicles' real-time locations on a map.
Los Angeles DOT/ LACMTA	The system uses loop detectors to determine location of buses and provides real-time arrival information on DMSs at Metro Rapid bus stops.
San Luis Obispo Transit, CA	A GPS-based AVL system providing real-time arrival information at selected bus stops.
Washington State Ferries	An Internet application that provides real-time information on the location of vessels by displaying their real-time location on a map; also Ferry Cams show images of ferries and ferry docks**.**
Denver RTD	Internet interactive voice response telephone and mobile applications to provide real-time arrival information.
Seattle, WA (King County Metro)	*BusView*, which provides real-time bus location and other real-time information, and *MyBus*, which provides to the Internet and mobile phones real-time arrival information.
Montgomery County Transit (Rockville, MD)	Cable TV channel with traffic cameras and other traffic and transit information. Web page, kiosks and electronic signs provide static schedule information.
Société de Transport de la Communauté Urbaine de Montréal (Montréal, Quebec)	*Tous Azimuts* itinerary-planning system provides door-to-door public transit directions using a web interface.
Ohio State University (Columbus, OH)	*Bus Location and Information System* provides real-time bus arrival and location information via a website and message signs at bus stops.
Tri-Met (Portland, OR)	*Transit Time Internet Access* web application that allows users to receive real-time schedule information about a bus they intend to ride. Real-time arrival information is also available at a number of bus shelters via DMSs.
Baruch College *and* MTA Long Island Rail Road (New York, NY)	*Talking Directory Display System,* a "talking kiosk" providing station information for the visually impaired.
San Francisco Bay Area	*TakeTransit* is an itinerary planner for the whole Bay Area and *TravInfo* is a telephone-based traveler information system.
Utah Transit Authority	*UTA Itinerary Planner, UTA My Way!* and *UTA on the Go!*

relays the message to a wireless CDPD/IP modem built into the DMS at the target bus stop. Each modem in the DMS has its own unique IP address, so a series of stop-specific messages can be cascaded along the route to update passengers as to when a Metro Rapid bus will arrive at their particular location.

Real-time bus arrival information is available only through the DMSs at Metro Rapid bus stops at this time, although providing this information on other media is planned for the future. LACMTA and LADOT are considering expanding the system to the Internet and possibly WAP mobile telephones and PDAs. The agencies are also discussing providing real-time information for rail (both heavy and light rail).

5.1.3 SLO Transit

In 2001 in San Luis Obispo, SLO Transit completed the installation of a prototype ITS system on its buses and at bus stops to test the operational suitability of ITS technology in a small transit agency environment. The project consisted of installing CAD software at the dispatch center; equipping 18 vehicles with GPS-based AVL hardware and software (including MDTs); and equipping eight bus stops with DMSs. The signs display the number of minutes until the bus arrival (see Figure 21). The signs are solar powered and controlled by wireless links.

The system utilizes a GPS-based AVL system. Rather than transmit the location information from the vehicles to dispatch over a specialized communication system, the system developers chose to "piggy-back" the digital data on the standard analog voice radio system that is used by SLO Transit to communicate with the drivers. This technique is possible in a smaller system because there is often unused radio channel capacity, and short data transmissions can use the "gap" between voice transmissions without interfering with normal voice communications. The onboard MDTs calculate schedule adherence status for arrival and departure from scheduled stops. Schedule adherence status is displayed to the driver and transmitted to the dispatch center (see Figure 26). The

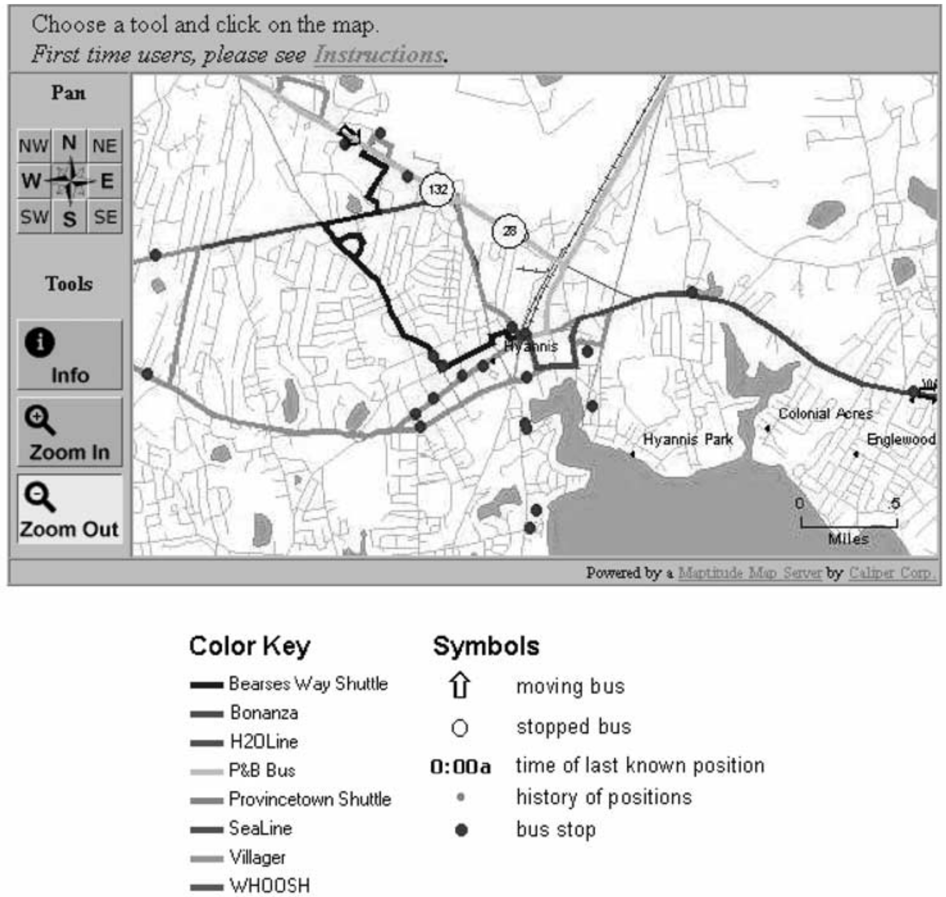


Figure 24. CCRTA advanced travel planner.

MDTs also notify the drivers of when they should be departing a stop with a layover.

Another innovative technique being used at SLO Transit lowers the operational cost of communicating with the DMS units deployed at the bus stops. These units have a built-in intelligence module that allows all deployed signs to listen to a single, bundled text message sent by way of a pager. This one message contains the updated data for all signs at all stops. Each Smart Transit Sign is programmed to know the bus stop(s) and bus route(s) it is servicing. Once the text message is received, the "smart" sign strips out irrelevant information and uses only the information meant for its specific location. It then uses this information to inform the waiting passengers of the time remaining until the bus arrives at that specific bus stop. This technique allows the transit agency to limit its Smart Transit Sign communication costs.

Figure 25. LACMTA Metro Rapid bus stop shelter sign.

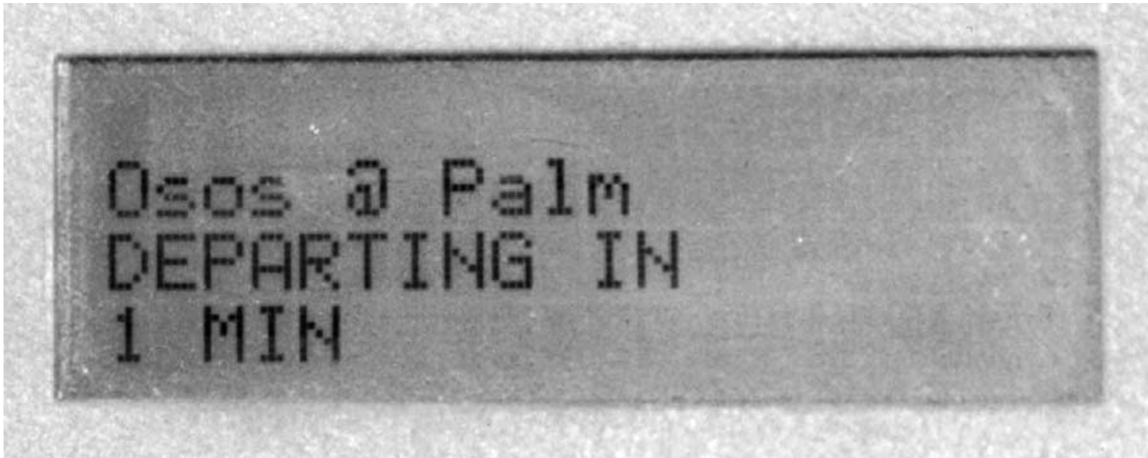


Figure 26. SLO Transit MDT screen (2).

The current system provides real-time information on arrival times of buses, location of buses, and service delays or disruptions. However, vehicle locations are available only on the dispatchers' monitors because the DMSs do not have the capability to display graphics. SLO Transit has considered the possibility of providing vehicle location and real-time arrival information via media such as the Internet.

5.1.4 WSF

In Washington State, WSF's Vessel Watch is an Internet application that provides information on the location of vessels by tracking the vessels and displaying their real-time location on a map. The real-time vehicle location is collected from the vessels through a GPS-based AVL system, which was installed 10 years ago in 1993 as part of Coast Guard operations. The vessel locations are shown for a route selected from a drop-down menu. The route names are also represented on the map alongside the moving arrows, which indicate vessel movement and direction (see Figure 16). The location information is updated every 3 minutes. This system was developed in-house with help from contractors from Washington State DOT.

The location information from the vessels' onboard AVL system is relayed to WSF through a private provider. The provider owns the infrastructure (towers and the frequency) and relays the information from the vessel to the WSF dispatching center as part of the AVL system. The AVL system also provides WSF with more detail on each vessel's operation, detail that is used to generate reports for analysis. WSF pays the provider a flat rate per hour per vessel to use the communications infrastructure. The location data that is relayed from the provider is then displayed on Vessel Watch.

The agency provides information through e-mail alerts to its subscribers. The alerts can be personalized to a selected route. These alerts are not in real time and are currently sent 24 hours prior to a vessel not being available for service and removed from the schedule. WSF currently has over 9,000 subscribers to the e-mail alert system.

WSF is currently providing real-time images of ferries through "Ferry Cams." WSF owns and operates some of the cameras and provides shots on www.wsdot.wa.gov/ferries/cameras/ (see Figures 27 and 28). In the locations that did not originally have cameras, a partnership between WSF and private companies that wanted to advertise enabled the installation and maintenance of the cameras at some locations.

5.1.5 Denver RTD

After acquiring its AVL system in 1996, Denver RTD was interested in using this technology to provide better service to its customers by means of supplying more reliable and accurate information. Currently, RTD provides traveler information to its customers through a variety of means including the Internet, telephone, wireless devices, and kiosks.

Since 1999, Denver RTD has been providing ETAs for its bus and rail services through its Bus Locator application on the Internet (www.rtd-denver.com). Bus Locator provides the ETAs for the next two to three vehicles at a particular stop. The application automatically switches to showing scheduled arrival times whenever real-time data is not available. Real-time location for buses is provided via the existing AVL system, while train location is provided via loop sensors.

In December 2001, Denver RTD implemented its Talk-n-Ride system. Talk-n-Ride is an IVR system that provides real-time bus and train arrival information. To use the system, users are prompted to speak the route number, direction, stop name, and time of their intended trip. The system also prompts the user to select whether he or she wants the scheduled or real-time arrival information. Once all the necessary information is entered, the system presents ETAs for the next three vehicles. Talk-n-Ride uses the same server that is used to provide real-

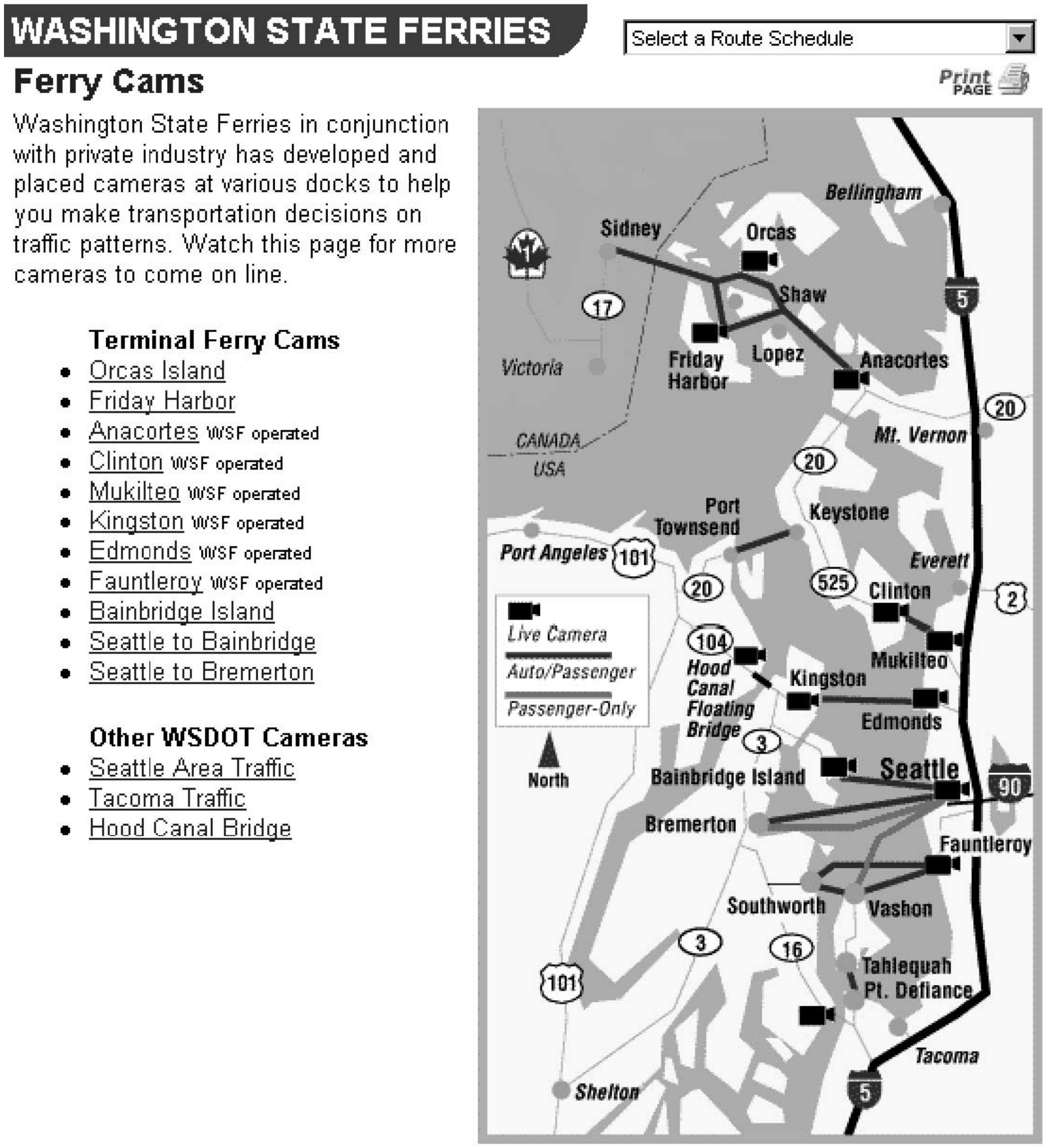


Figure 27. WSF Ferry Cam selection.

Figure 28. Ferry Cam image.

time arrival information in Bus Locator. Talk-n-Ride uses text-to-speech (TTS) technology to convert information generated by the system into voice. It is estimated that the call volume for Talk-n-Ride has been approximately 1,800 calls per month, with an average of 1 minute and 26 seconds per call. RTD pays the company that hosts the Talk-n-Ride system a flat rate of 12¢ per minute. At a minimum, RTD pays the host $500 per month if call volumes do not reach the equivalent of $500.

Mobile-n-Ride is another application through which Denver RTD provides real-time arrival information to its customers. RTD provides PDA and web-enabled mobile telephone access to real-time information in this system, using the same customer inputs as Talk-n-Ride. The same server and software is used to provide ETAs via a PDA and mobile telephone as is used for the Talk-n-Ride and Bus Locator applications. An interpreter program determines the type of device that is requesting ETA information and the operating system being used by that device. Once the system determines the device type and the related operating system, the ETA prediction is calculated and provided to the requesting device in the correct code (which is determined by the device's operating system). For example, data is returned in WML 2.0 if the mobile telephone that is requesting the ETA information is running WML 2.0. A total of 440 devices and multiple versions of XML, WML, and HTML are supported.

Denver RTD also provides various types of information to its customers via kiosks (see Figure 29). Currently, there are about 60 kiosks located across the city at most RTD facilities and at many public facilities. At the kiosks, users can check route and schedule information, view maps, get information on RTD programs and services, and plan their trip using the RTD Itinerary Planner. Users also have access to real-time information as the kiosks provide access to RTD's Internet site.

Finally, Denver RTD is currently testing the use of DMSs at selected stops along five routes (B, B Local, B Express, 2, and 12). This demonstration system, which will consist of 20 electronic signs, is expected to be operational by the end of 2002. This system, provided by a third-party vendor, will use RTD's location data (generated by the existing AVL system) with the vendor's algorithm to predict arrival times. Also, the vendor will provide this real-time information on RTD's website, where users can access route maps and get arrival times at all stops along the route.

5.1.6 King County Metro

Seattle's King County Metro is another agency that provides comprehensive traveler information to its customers.

Figure 29. RTD's kiosk.

The agency provides an itinerary-planning system (see Section 3.1.2, Figure 1) in addition to specialized real-time applications called BusView and MyBus. These applications were developed in part with funds for Seattle's Smart Trek MMDI.

BusView is an Internet application developed at the University of Washington. It displays a map of the current locations of all Metro buses currently in service (see Figure 14). The service became available via the Smart Trek website in 1998. BusView is capable of displaying the location of 1,300 Metro buses traveling on 250 routes throughout its service area. In order to use the raw bus location information from Metro's AVL system to predict real-time arrival times, onboard hardware and software had to be upgraded. The Internet interface for BusView is a Java software application that runs on almost any computer platform, including Macintosh, personal computers (PCs), and Unix.

BusView displays a window showing a map of a specific area with bus routes highlighted and bus locations displayed along the routes. A specific geographical location can be selected from a preselected list of locations from a drop-down menu. The user can pan the map as well as zoom in and zoom out (although zooming is limited to 1-mile and 2-mile views). When several routes run on the same alignment, within the displayed map the view becomes cluttered with routes and buses. Hence, the application allows the user to filter out all unwanted routes by entering the route number that most concerns him or her in the "Busses to Display on Map" box.

Another interesting feature of BusView is that it allows the user to request that the system alert him or her when his or her bus is approaching a specific location. To achieve this, the user can either right click on a bus icon and then select "Bus Progress" or enter a route number in the "Route Progress" box. Using the right-click method will show a linear representation of the bus route (see Figure 15). Using the "Route Progress" box method allows the user to enter an origin and destination. A window will then display the segment of the route indicated by the origination and destination entered. With the linear representation of the route displayed, using either method, the user can click anywhere along the route to place an alert request. When the next bus arrives at the location where the alert was placed, the application will produce an audible and visual notification. This is helpful as one can insert an alert several blocks from where the customer catches the bus, allowing the customer enough time to get to the bus stop.

MyBus is another application that provides real-time arrival information on Metro's bus routes via the Internet or on wireless devices such as mobile phones and PDAs. MyBus was initially developed at the University of Washington, with funding partially provided by the federally sponsored "SmarTrek" MMDI project (*3*). King County Metro does not currently maintain MyBus, but the agency is planning to take over the operation and maintenance of MyBus in 2003.

The web service was initially developed to provide real-time predictions of bus arrival and departure times at eight key transfer points in the King County Metro transit network, particularly at selected transit centers and park-and-ride lots. The original system even showed the customer which bus bay each route was arriving at or departing from. MyBus has now been expanded to so many locations that a map of the region broken into smaller zones is provided to help customers find the desired MyBus transit node. Note that customers can bookmark any “MyBus location” once they have found the locations that interest them. MyBus also uses information from King County Metro’s AVL system and the prediction algorithm developed by the University of Washington to make its arrival and departure estimates (*4*). Readers may want to note that the vehicle location information comes from a signpost-based AVL system.

The Internet version of MyBus prompts the user to click on a King County map to select a particular section of the county. Then the user selects the bus stop of his or her choice. MyBus then lists all the buses running on the routes that serve the selected bus stop in a table format. The user has the option to sort the table by scheduled time, destination, or route (see Figure 30). The user can also click a button on the screen to generate a map showing the location of the bus stop he or she has selected.

Another recent development is that MyBus information can be accessed by WAP-enabled cell telephones or networked Palm Pilot PDAs (*5*). This option has been available since 2001. The information is edited and formatted differently for these devices than for PC web browsers. Figure 31 shows an example screen for WAP-based information. Figure 32 shows the information displayed on a Palm Pilot.

5.1.7 Montgomery County Transportation Management Center

In Maryland in September 1996, the Montgomery County Transportation Management Center (TMC) started integrated traffic and transit operations (*6*):

> The Ride On transit dispatchers and supervisors were relocated to the TMC and joined traffic technicians and engineers to manage the County’s transportation system. This integration of traffic and transit operations was made to improve coordination between traffic engineering and transit services, and ultimately, to ensure the efficient utilization of transportation capacity in the County. Through one system, the Advanced Transportation Management System (ATMS), transit and traffic operations are performed.

37 AV SW & SW ALASKA ST(farside)

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

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

Show Location List | Show Location Map

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

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

Figure 30. King County Metro MyBus information.

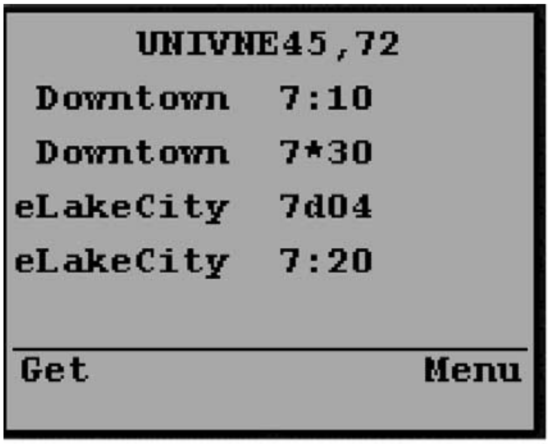


Figure 31. MyBus display on WAP-enabled cell phone.

Montgomery County's Department of Public Works and Transportation provides traffic and transit information via cable television, radio, a website (*7*), three kiosks, and four DMSs. Two of the kiosks are near the county government center in Rockville; the third is within a shopping mall. The electronic signs are installed at subway stations and bus shelters. The Travelers Advisory Radio System (TARS) covers approximately 10% of Montgomery County with 12 low-wattage transmitters using 590 AM or 1070 AM. The same audio used for the TARS is broadcast on County Cable 55 and the Internet. TARS messages provide motorists with information on incidents, construction, maintenance activities, and special events. TARS is also used to enhance safety and to manage traffic flow by diverting travelers to less congested roadways. TMC technicians update TARS messages with real-time transportation information related to traffic and transit.

Figure 32. MyBus display on a wireless PDA.

Via the cable TV channel and radio broadcasts, passengers can receive updated information on traffic conditions, accidents, and public transit delays. The web page provides route, schedule, and fare information. The website offers the user links to websites of all transit providers in the region (including Washington, D.C., and northern Virginia), including WMATA's RideGuide. The website also offers information on road delays and incidents, as well as real-time snow-removal information. The electronic signs provide static route and schedule information although real-time information is expected to be added in the near future.

5.1.8 Société de Transport de la Communauté Urbaine de Montréal

In Québec, the website for Montréal's Société de Transport de la Communauté Urbaine de Montréal (STCUM) includes a sophisticated itinerary-planning system named Tous Azimuts (*8*). The system provides complete bus and subway trip-planning information between any two points within Montréal. Service is provided in French and English. Passengers accessing the website use a point-and-click map of Montréal to specify their origins and destinations (see Figures 33 and 34). If users do not want to use the map to specify origins and destinations, they can use a text search. The text search can find an intersection, an address, a Metro or train station, and key points of interest by name. The system asks for the day and time of the trip, the preferred mode (bus or subway), and whether the routing algorithm should include a penalty for walking (see Figure 35). From this information, the system calculates and presents one or more optimal itineraries (see Figure 36). Passengers are asked to telephone the STCUM's automated bus information system to verify the bus arrival times on the itinerary.

5.1.9 Ohio State University Bus Location Information System

The Ohio State University (OSU) Center for Intelligent Transportation Research was approached by OSU Transportation and Parking Services with a proposal to provide real-time information about bus arrivals to riders waiting at bus stops. A joint project, known as the OSU Bus Location Information System (BLIS) and funded internally by Transportation and Parking Services, arose from those meetings. OSU BLIS provides real-time bus location and arrival time information to passengers of the extensive campus bus system. The

Figure 33. Tous Azimuts initial screen.

system uses a GPS-based AVL system to provide bus location information over the Internet and bus arrival information via DMSs installed at the bus stops. The system also archives the bus location data, and these are used by OSU Transportation and Parking to evaluate bus service. The hardware and software used in this project were designed, manufactured, and implemented as a student project within the OSU College of Engineering and the OSU Center for Intelligent Transportation Research. The system was deployed in September 1997.

A GPS-based AVL system was designed, manufactured, and installed on each of the 18 campus buses. Via CDPD modems, data from the buses are relayed to a central computer. This data is used to provide real-time bus location information through a Java-based website (*9*), waiting time estimates that are displayed on DMSs at the bus stops, and historical and statistical information about the performance of the campus bus service. The system provides three types of information. First, at each bus stop, passengers can obtain minimum estimated wait times for each bus on the route via programmable message signs installed at the stop. Second, pre-trip information is also available via a website that displays, in real time, the location of all campus buses. Third, the central computer stores historical and statistical information about the performance of the campus bus service, which is used both by OSU Transportation and Parking to evaluate bus service and by students in a traffic management course.

5.1.10 Tri-Met's Transit Tracker

In Oregon, Portland Tri-Met's Transit Tracker is a traveler information system that provides real-time transit information via the Internet and through LED DMSs at several bus stops and light rail stations. Transit Tracker uses a GPS-based AVL system to determine bus locations and loop sensors to determine train locations. The first Transit Tracker sign was installed in January 2001 at one key bus stop. As of September 2002, 11 displays have been installed at 10 bus shelter locations and 28 signs at 11 MAX stations (see Figures 2 and 22). Tri-Met plans to install 50 signs by mid 2003, with an ultimate goal of installing a total of 250 signs throughout the service area. The difference between signs at bus shelters and those installed at MAX stations is that the former provide real-time arrival information while the latter show only scheduled arrival time. Bus stops that serve more than one route

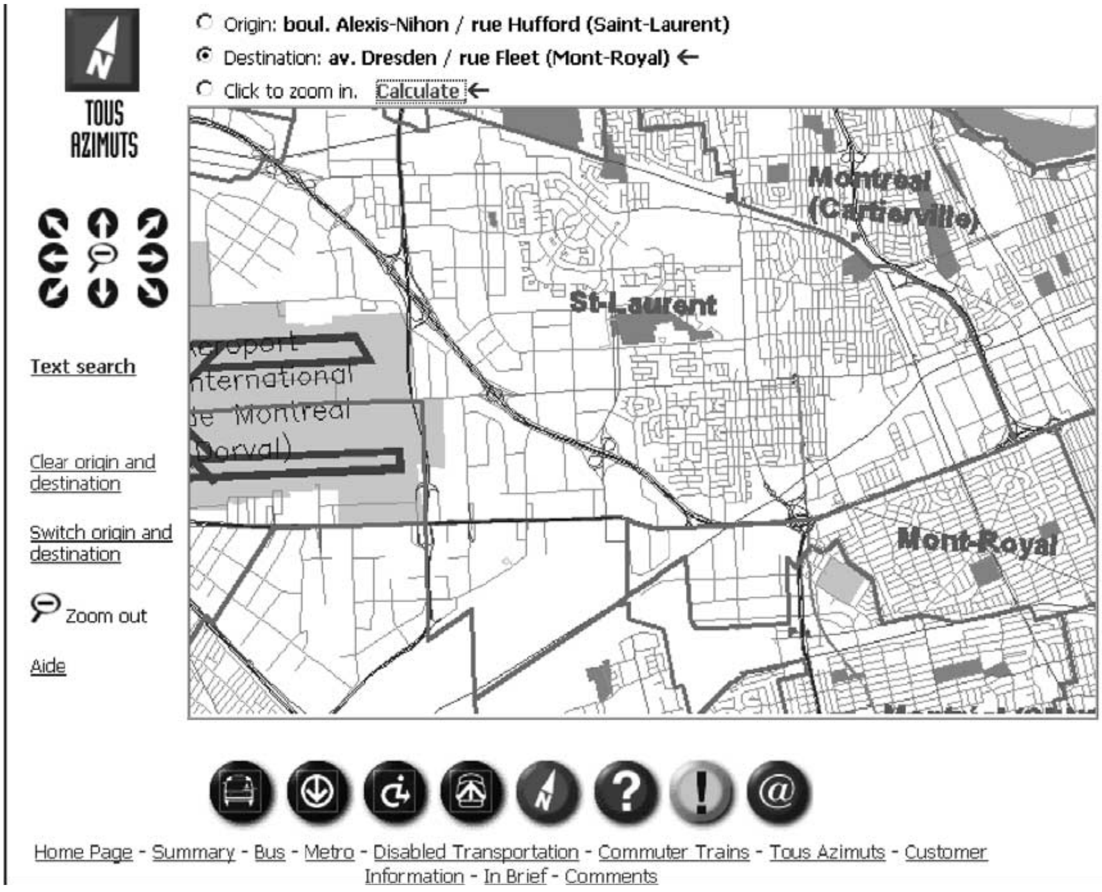


Figure 34. Tous Azimuts origin and destination selection.

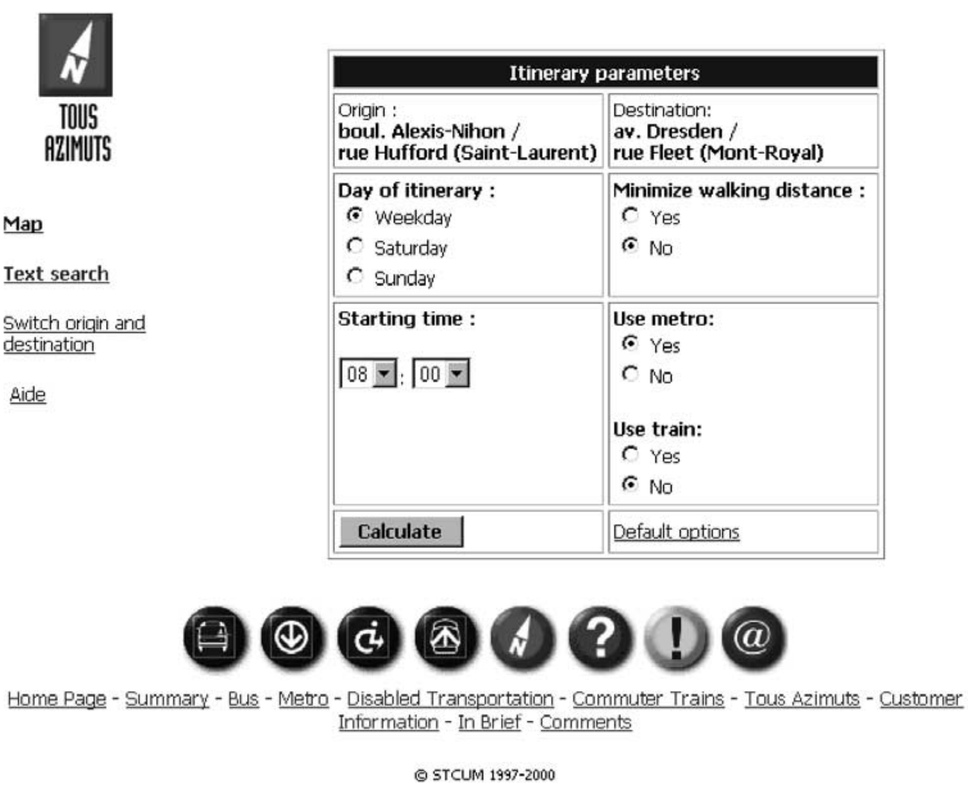
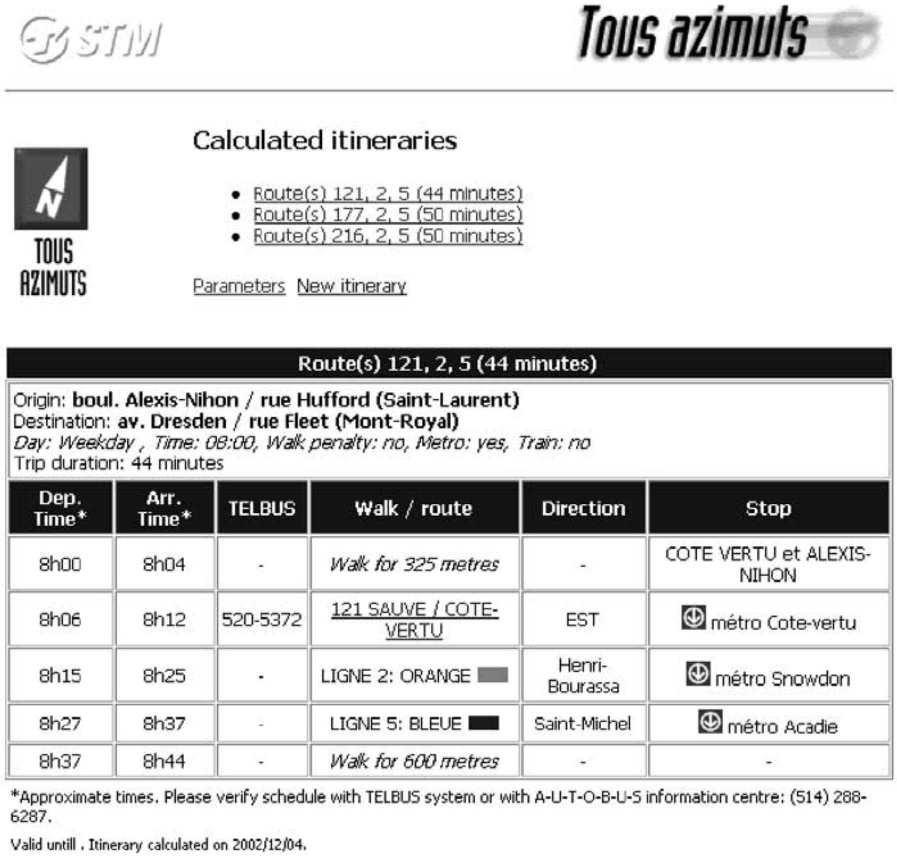


Figure 35. Tous Azimuts itinerary parameters.



STM Tous azimuts

TOUS AZIMUTS

Calculated itineraries

- Route(s) 121, 2, 5 (44 minutes)
- Route(s) 177, 2, 5 (50 minutes)
- Route(s) 216, 2, 5 (50 minutes)

Parameters New itinerary

Route(s) 121, 2, 5 (44 minutes)

Origin: **boul. Alexis-Nihon / rue Hufford (Saint-Laurent)**
Destination: **av. Dresden / rue Fleet (Mont-Royal)**
Day: Weekday , Time: 08:00, Walk penalty: no, Metro: yes, Train: no
Trip duration: 44 minutes

Dep. Time*	Arr. Time*	TELBUS	Walk / route	Direction	Stop
8h00	8h04	-	*Walk for 325 metres*	-	COTE VERTU et ALEXIS-NIHON
8h06	8h12	520-5372	121 SAUVE / COTE-VERTU	EST	métro Cote-vertu
8h15	8h25	-	LIGNE 2: ORANGE	Henri-Bourassa	métro Snowdon
8h27	8h37	-	LIGNE 5: BLEUE	Saint-Michel	métro Acadie
8h37	8h44	-	*Walk for 600 metres*	-	-

*Approximate times. Please verify schedule with TELBUS system or with A-U-T-O-B-U-S information centre: (514) 288-6287.

Valid untill . Itinerary calculated on 2002/12/04.

Figure 36. Tous Azimuts itinerary.

are outfitted with a multiline LED display to list arrival information for three or four buses.

The Transit Tracker Internet application (www.tri-met.org) provides real-time information for almost all bus stops in the Tri-Met system (approximately 8,000 bus stops) (see Figure 13). The Internet application has been in use since September 2002. The user is prompted to select the route, the direction, and the specific bus stop of his or her choice. The application then displays the ETA of the next bus.

Arrival times of buses are not generated by means of a prediction algorithm as in the case of most other systems; a bus's arrival time is, however, based on the schedule adherence status of the bus. Transit Tracker, using location and schedule data, determines how early or late a bus is running. This information—schedule adherence and block number—is then broadcast to all signs that already have stored all the schedules by block numbers in an internal memory unit. Once a sign receives an arrival time message, it compares the received data with the schedule. The sign's internal processor determines what the offset from the schedule is and then displays the expected arrival time in a countdown fashion.

Tri-Met is currently developing an in-house application to provide real-time information on wireless devices such as PDAs and mobile telephones. It is expected that this application will be operational in the early part of 2003. A recent survey study conducted by Tri-Met (see Section 3.1.2.5) revealed that its passengers place a very high value on having Transit Tracker at their stop. When asked how much value they place on having Transit Tracker at their bus stops, 60% of the respondents assigned a value of 5 on a scale of 1 to 5 (with 5 being the highest) and 25% gave it a value of 4. Moreover, 75% of all respondents indicated that they "check the information" on the Transit Tracker display *always* and 21% check the Transit Tracker *sometimes.*

5.1.11 Metropolitan Transportation Authority Long Island Rail Road

The Talking Directory Display System (TDDS) is a joint project of the Baruch College Computer Center for Visually Impaired People (CCVIP) and New York's Metropolitan Transportation Authority (MTA) Long Island Rail Road (LIRR). TDDS, nicknamed the "Talking Kiosk," was specially designed to assist persons who have visual impairments with locating LIRR facilities throughout Penn Station and in New York City. The kiosk was deployed in July 1999.

TDDS was developed at the Baruch College CCVIP in close collaboration with the American Foundation for the Blind and the Stein Partnership (*10*). Baruch College staff were responsible for system design, software development, and maintenance.

LIRR staff were responsible for identifying a suitable location for the unit and briefing personnel about the kiosk's existence and function. TDDS employs state-of-the-art multimedia technology and uses a raised line map, large print, and speech to present expertly crafted way-finding information to help users who have visual impairments navigate through complex spaces. The pilot use of the kiosk began in September 1996.

TDDS is a three-sided structure housing computers, speakers, a touch tablet with a tactile map, and a touch-tone type keypad. When not in use, the system remains in attract mode in which it speaks, announcing its presence and inviting the user to try it. As users approaches the kiosk, a proximity detector senses them and the session begins. Users are invited to place their hands on the counter in front of them, where they find a raised line tactile map with large print underneath and a keypad similar to that used on a touch-tone telephone. Information can be accessed either through a voice mail–type menu system activated through the keypad or through a "touch-and-tell" mode activated by pressing a point on the raised line map and hearing the information spoken. In the "touch-and-tell" mode, three levels of information are available:

1. The user can touch a point on the map and hear the location spoken by the system;
2. If the user keeps his or her finger on that point, the user will hear additional information concerning the way to find it; and
3. If the user continues to hold his or her finger on that point, the user will hear what is available at that point.

The "touch-and-tell" mode is always active; thus, a user can choose to work primarily through the menu system and can then explore the map to reinforce his or her mental picture of the route from the kiosk to the destination. All spoken messages are displayed in large print for the benefit of the many people with visual impairments who have some useable vision. It has been found that the TDDS is useful for many customers who do not have severe visual impairments, but who find it difficult to deal with the customary sources of information. Information provided at the kiosk includes a station overview and complete information on the railroad, including information on LIRR destinations, specific tracks, specific boarding corridors, the ticketed customer waiting room, the lost and found, and more. Location information is provided for New York City Subway service, Amtrak, New Jersey Transit, and the locations of major station exits.

The kiosk has a call-in feature that allows Penn Station personnel to call and record by phone a message so that the user gets the information immediately—for example, such a message might be that an exit has to be closed for a day or an elevator is out of service. Finally, the system collects data on each user, including the length of each session, what type of information was requested, and which modes of information access were used. At the end of the session, the user is offered the opportunity to respond to several short questions assessing his or her satisfaction with and the usefulness of the TDDS.

In a 3-month period during the demonstration, the TDDS was used almost 13,000 times. It was estimated that around 99% of the usage was by persons with no visual impairment. A detailed evaluation of the system involving a series of trials by the visually impaired showed that TDDS was user-friendly, that more people use the key pad than the map, and that 18 out of 20 people who successfully completed the trial would use the TDDS again (*11*). Although the keypad was used more frequently, the evaluation found that users would also employ the map once they had become familiar with the general working of the system. The majority of participants indicated they would like to have similar installations in other locations.

5.1.12 San Francisco Bay Area Metropolitan Transportation Commission

The Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area provides two TTI systems: the web-based TakeTransit itinerary-planning system and TravInfo, a multimodal telephone and Internet traveler information system. As part of its overall commitment to multimodal traveler information, MTC took the lead in creating the multi-organizational TravInfo system (*12*). The multimodal effort was initiated in 1993 as a field operational test (FOT) sponsored by U.S. DOT. One of the first projects was to create a telephone operator–based system of integrated travel information and trip planning. Both the telephone services and the AIP systems are available in MTC's nine-county service area.

The itinerary planner was launched on the MTC web page in July 2001. MTC's itinerary planner was designed to provide transit customers with consistent trip itinerary information across modes and transit service providers. This means that a customer wanting to take trips that involve more than one agency or cross service areas or modes need not be concerned with different agencies and their service boundaries. This approach is especially important for multimodal services with dense transit service across an entire region. The web-based AIP information is available to customers at their fingertips, 24 hours per day.

As shown in Figure 37, the MTC trip planner allows its customers to identify origins and destinations by address, intersection, or landmark. Customers can also define the day of their trip, departure time, and other options as follows:

- Itinerary preference (e.g., fastest itinerary, fewest transfers, minimal walking, or lowest fare);
- Fare category (e.g., adult, senior, disabled, child, youth, or school trip); and
- Maximum walking distance to the first leg of a trip (e.g., 1/8, 1/4, 1/2, 3/4, or 1 mile).

This interface provides a high degree of flexibility for defining trip-planning criteria. Like many other AIP systems deployed in the United States, all of the trip information is input on a single page. Another useful component is the "coverage area" map link on the main AIP page. Shown in Figure 38, the map allows customers to identify where

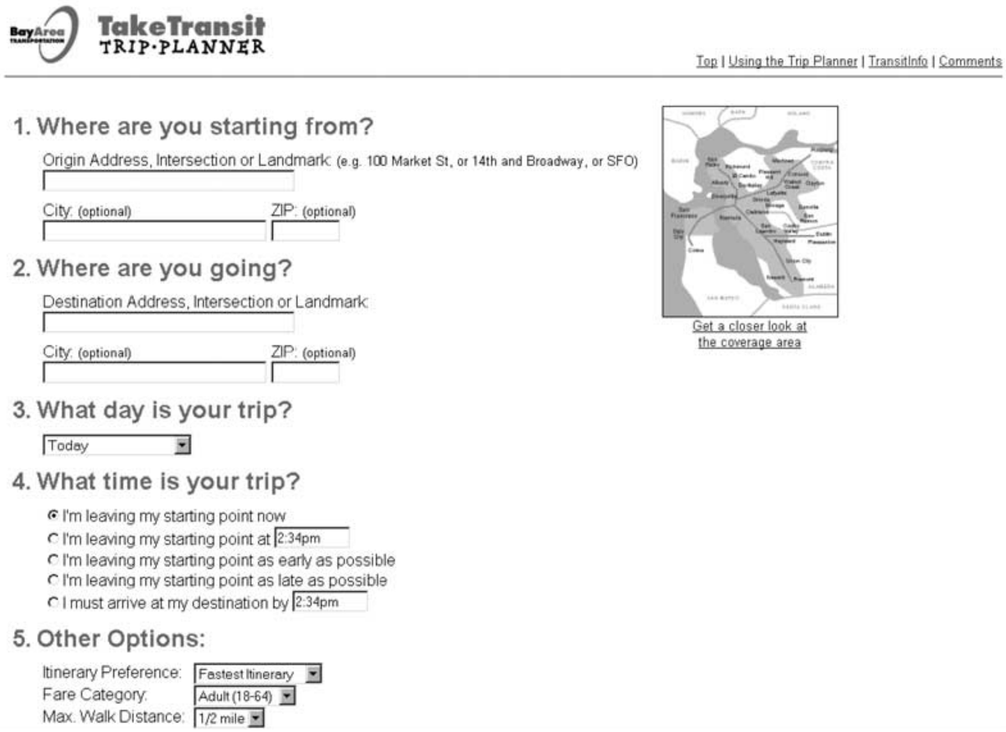


Figure 37. MTC TakeTransit input page.

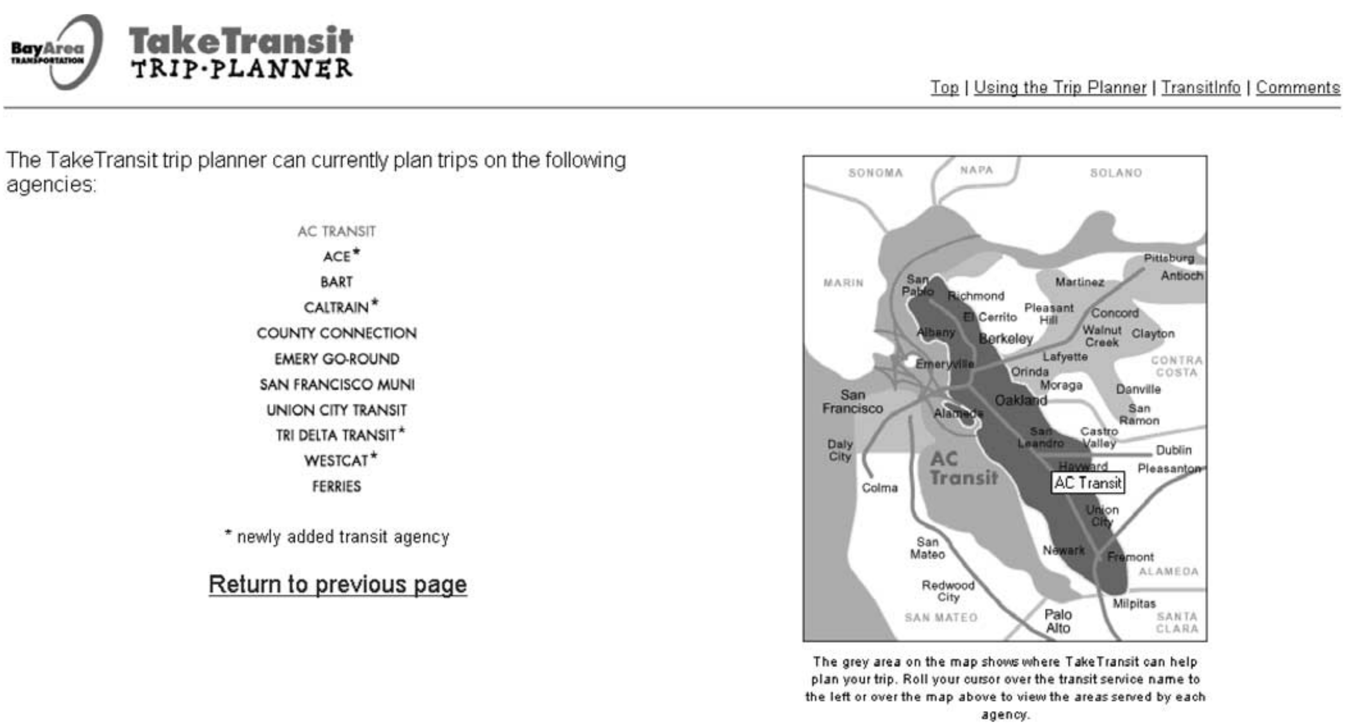


Figure 38. TakeTransit coverage area link.

agencies' coverage areas are by holding the cursor over the map, which turns the area green and labels it. For example, Figure 38 demonstrates this by showing the Alameda–Contra Costa Transit District's (AC Transit's) service area in dark gray and the service areas of other agencies included in the itinerary planner in a lighter gray. Further, the customer can click on the map to bring up detailed information about the agency. This feature includes both service areas for AC Transit, County Connection, Emery Go-Round, MUNI, Union City Transit, Tri-Delta Transit, and Westcat, as well as lines representing Caltrains, Bay Area Rapid Transit (BART), Bay Area Ferries, and Altamont Commuter Express services.

MTC's landmark error trapping feature, shown in Figure 39, allows a customer to respecify a landmark location if the AIP system does not recognize the initial input. MTC works closely with each of its member transit agencies to identify important landmarks—a list that is regularly updated. MTC assumes that customers use a combination of origin and destination types when creating an itinerary. The landmark list is in a typical database and is not geocoded. Figure 40 shows the output that the customer is given. Of particular note are the following features of the itinerary page:

- The walking maps and detail of the associated system map provided even for transfers,
- Fare by trip leg and total fare, and
- The Revise Your Trip feature.

The fare by trip leg is particularly important for regional multimodal itinerary-planning systems for which a leg on intercity rail could raise the fare significantly. Note that although only one itinerary is provided, unlike other AIP systems deployed in the United States, the Revise Your Trip feature makes it simple for the customer to modify the itinerary characteristics without having to start the process over.

5.1.13 Utah Transit Authority

The Utah Transit Authority (UTA) has a highly innovative program to personalize information to its customers based on their individual needs. While the agency does not send out "real-time" information per se, it provides notifications based on the tracking and monitoring of the conditions of the system. In addition, the website includes an automated itinerary trip planner.

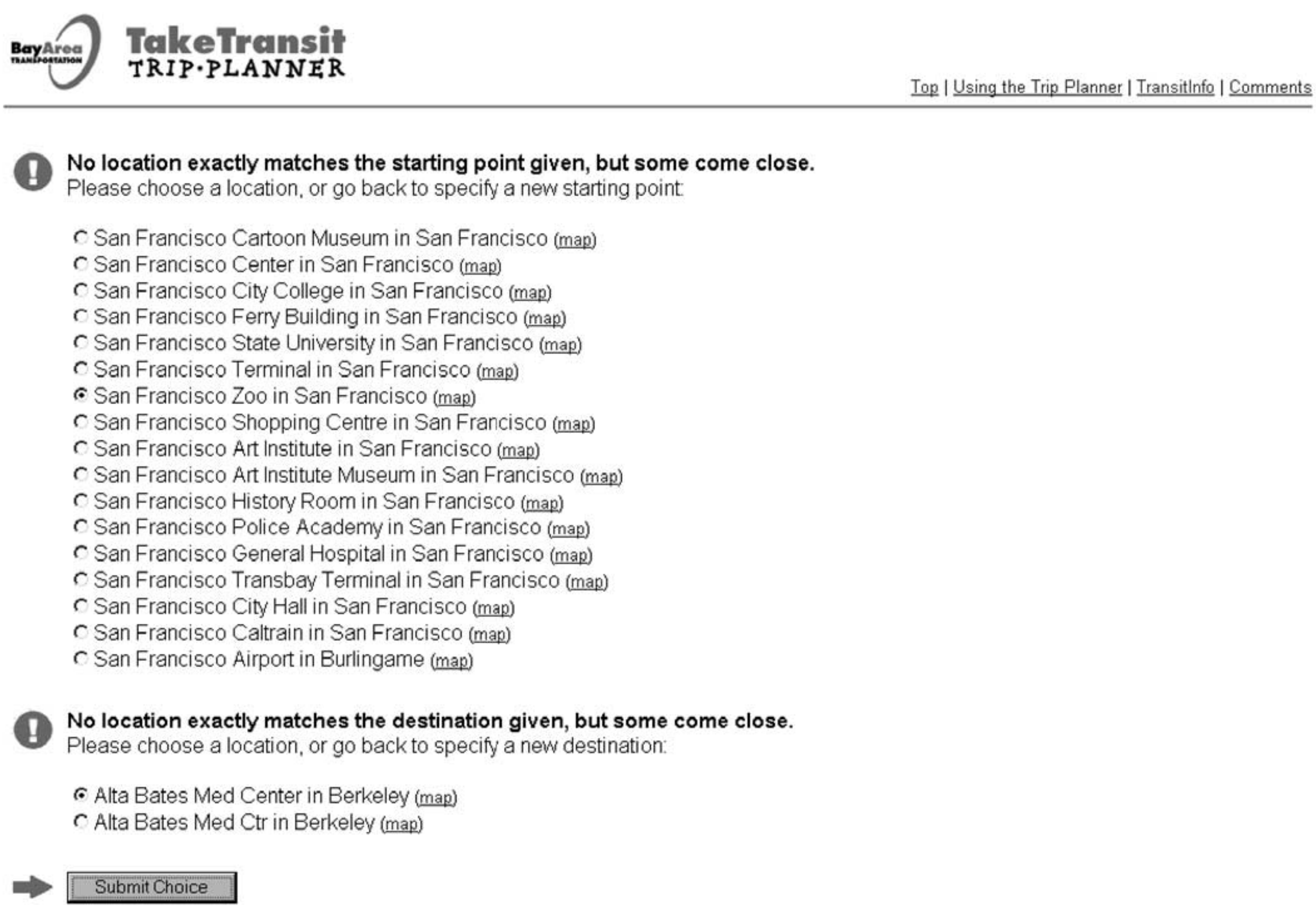


Figure 39. TakeTransit landmark correction page.

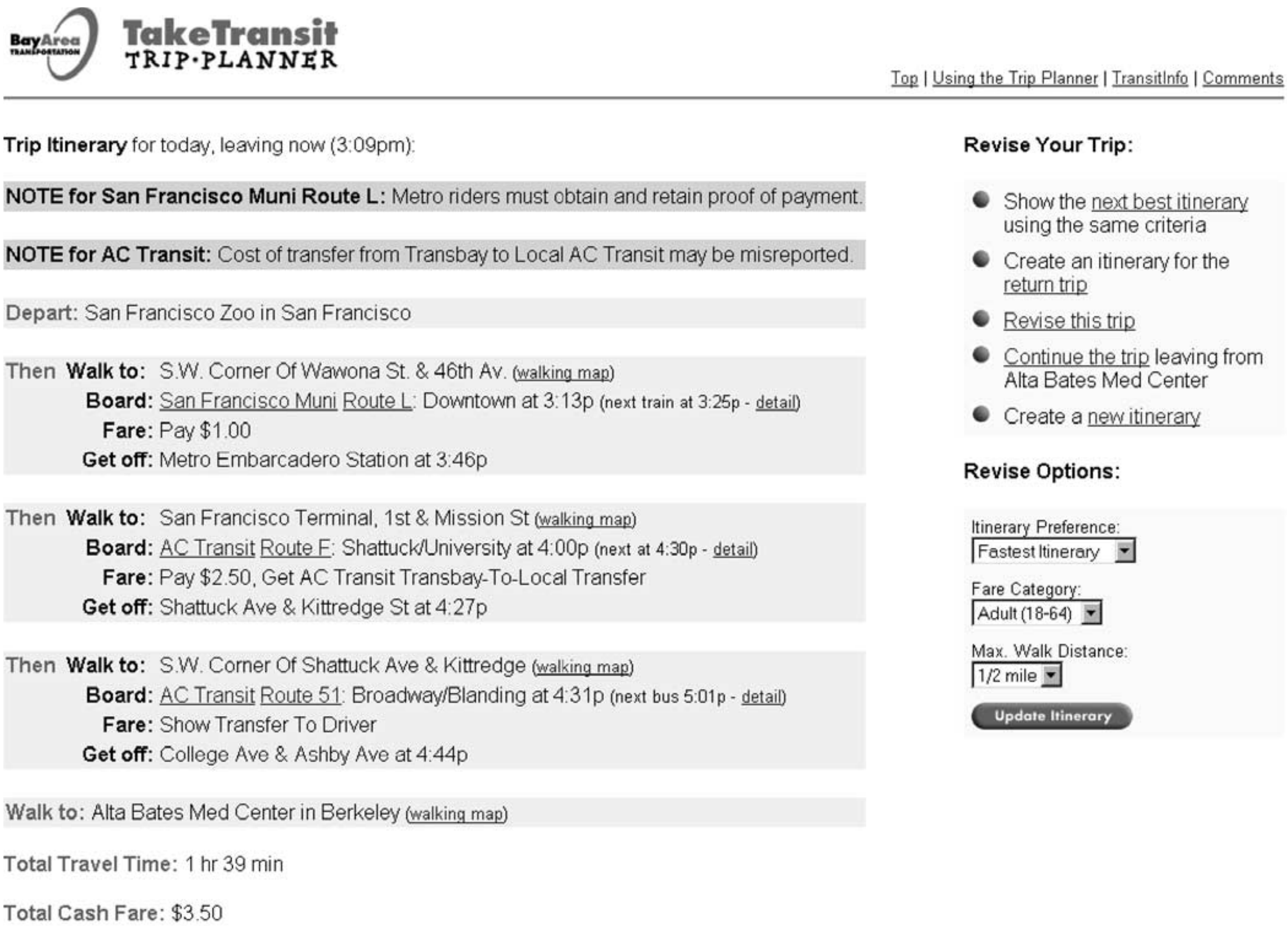


Figure 40. TakeTransit itinerary output.

UTA's primary goal is to reposition itself within the community and to be actively involved in making a better environment for the community. The web-based customer information allows the agency to develop a good relationship with its customers. The agency's goal has been to make public transportation more convenient and to have a friendly interface so that people are not afraid to ride the bus. The UTA Itinerary Planner has a user-friendly customer interface, which allows origins and destinations to be defined in terms of (1) addresses, (2) landmarks, and (3) categories of places. The three forms of input are placed on the same screen as the specification of date and time. The date is entered by use of a calendar for quick entry by clicking. As shown in Figure 41, when selecting categories of places, a pull-down list of those places is displayed. Figure 42 shows using a destination that was already used by the customer in a previous trip plan.

Figure 43 shows the screen that the customer uses to set the date and time of travel. Figure 44 illustrates the resulting itineraries. The trip planning results can be e-mailed, as shown in Figure 45.

In order to get e-mail notifications, customers must be registered with UTA My Way. By registering, customers also have the privilege of participating in surveys and new programs offered by UTA before nonregistered customers can. Once an individual picks his or her routes, information related to those routes (like disruptions) will pop up on the screen when the user logs on. Figure 46 shows the initial UTA My Way screen, and Figure 47 shows the personalization screen.

UTA My Way is geared more toward regular customers, while the trip planner is thought to increase the accessibility of the system for nontransit riders. UTA has found that having to register to use the service discourages people from using the trip planner (or other services), so UTA put the service on the general website. When UTA put the trip planner on the general website, usage increased by 1,000 hits in 1 week.

Figure 41. Result of category selection in UTA Trip Planner.

UTA On the GO! is a service UTA offers through AvantGo. The service allows customers to synchronize their PDAs and desktops to download schedule information. Using UTA On the GO! customers can download schedules to any handheld device. Ideally, UTA would like to have a push-pull system in which it would have account information for an individual, and UTA could send customers information on the handheld device as well as allowing them to pull information from the website. However, UTA has not done this yet. On the GO! was added in June 2000.

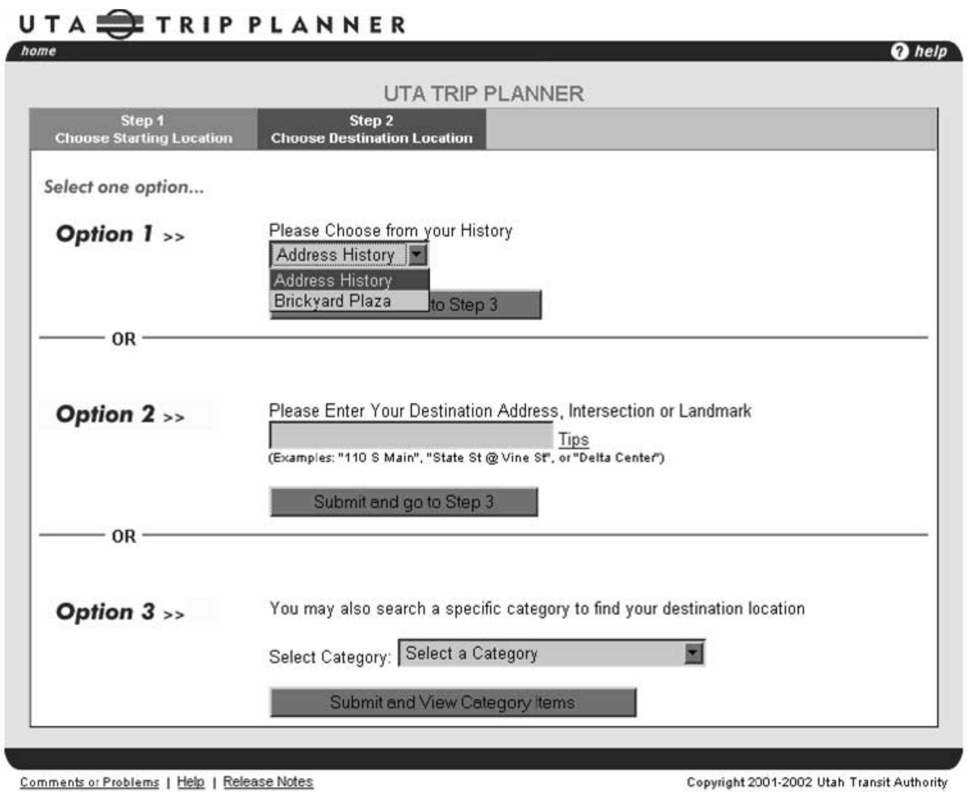


Figure 42. Step 2 of UTA Trip Planner, including address history.

Figure 43. Step 3 of UTA Trip Planner, including address history.

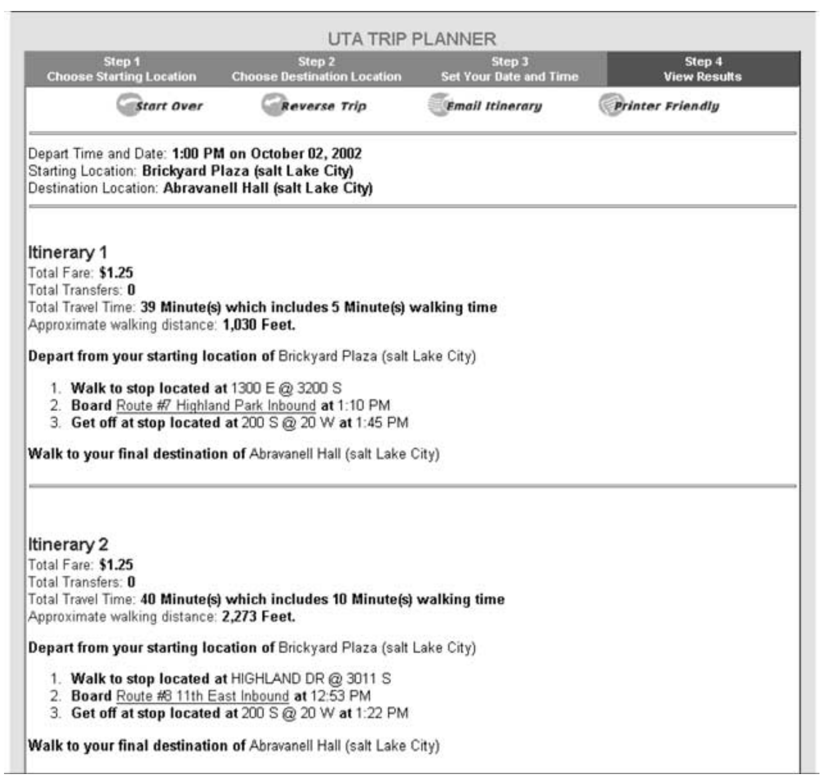


Figure 44. Itineraries produced using UTA Trip Planner.

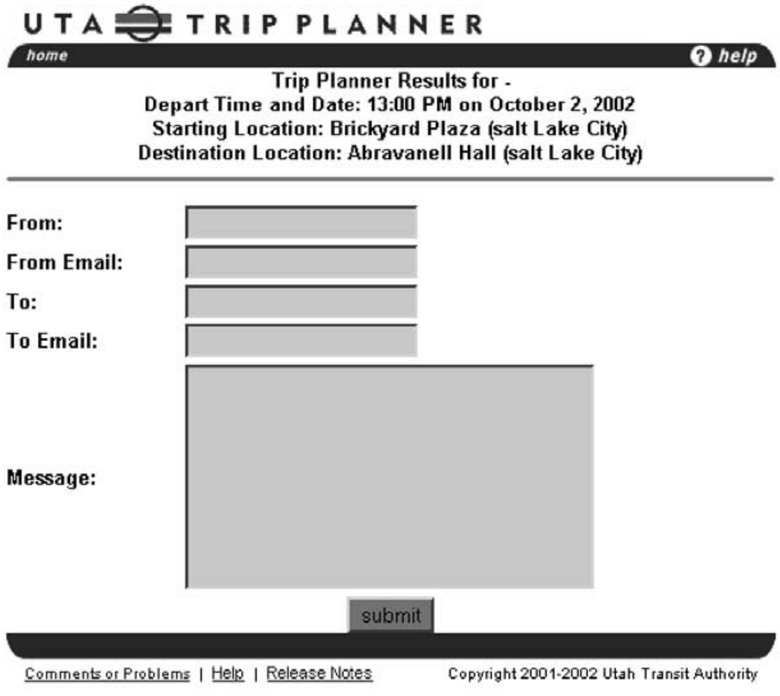


Figure 45. Trip Planner e-mail feature.

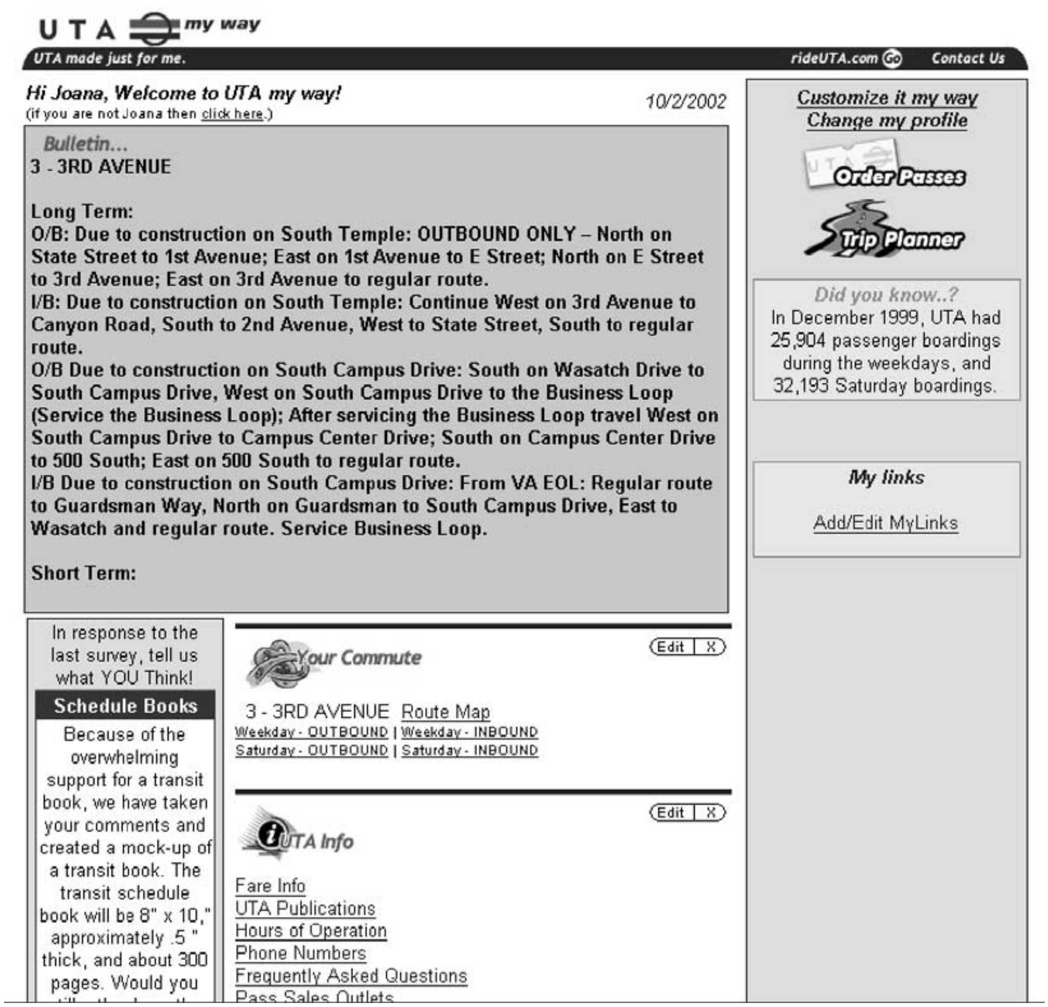


Figure 46. UTA My Way initial screen.

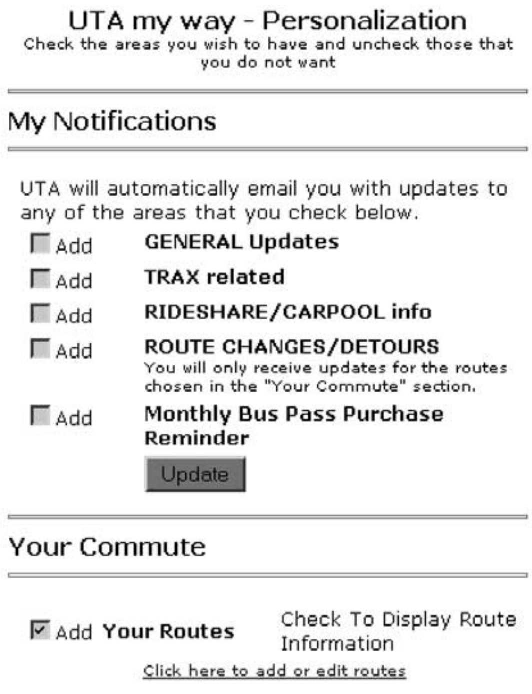


Figure 47. UTA My Way personalization screen.

5.2 EUROPEAN SYSTEMS

The European portion of the project focused on 10 initiatives designed to improve public transit information. Table 9 presents a summary of each project.

5.2.1 London, United Kingdom

Transport for London provides a variety of TTI services, including the Journey Planner (see Figures 48 and 49), real-time bus arrival information at bus stops throughout London (see Figure 50), and several other customer-oriented services such as bus stop-specific schedules and maps (described in Section 8.3). London was one of the first cities in the world to deploy LED signs at bus stops that indicate the arrival times of the next buses at each equipped stop. This system, called Countdown, was piloted in 1992 on bus Route 18. The results of surveys conducted during the pilot indicated that Countdown was highly popular with customers. In 1993 and 1994, Countdown was tested in several bus corridors. In 1996, a London-wide rollout of AVL and Countdown was approved. In 2001, the AVL program was 80% complete and the Countdown program was 25% complete (*13*). As of March 2002, 1,473 Countdown signs were installed and operational. The plan was to have a total of 2,400 signs installed by March 2003 and 4,000 signs by 2005. Four thousand signs cover 25% of all stops and will benefit 60% of all passenger journeys.

The approach for the implementation of Countdown has been to deploy the signs in boroughs where the buses have been equipped with AVL. There are 33 boroughs in London; as of March 2002, 14 have Countdown. Surveys suggest that Countdown has improved attitudes to bus travel, changed perceptions of wait time and level of service, influenced travel behavior, and had a positive effect on perceived security when passengers are traveling at night. According to Transport for London research, Countdown has been extremely well received by passengers and is reliable as well as accurate. Extensive surveys and monitoring have been undertaken throughout Countdown's operation and are continuing.

In terms of component reliability and system availability, the level of failures is low and the availability is over 99%. A survey conducted to assess information accuracy at 1,379 Countdown sites in the late 1990s revealed that

- Accuracy was within ±1 minute 50% of the time,
- Accuracy was within ±2 minutes 75% of the time, and
- Accuracy within ±5 minutes 96% of the time.

Countdown-style displays are now installed at many London Underground stations. While Countdown information is not currently provided via mobile media, other Transport for London services, such as the Journey Planner, are provided via cell phones and wireless PDAs using free SMS and WAP.

5.2.2 Helsinki, Finland

The greater Helsinki area is home to several TTI services, including Personal Mobile Traveler and Traffic Information Service (PROMISE); the Journey Planner; the Espoo and Länsiväylä Passenger Information System (ELMI); and Helsinki City Transport's real-time system (HELMI), which covers both bus and tramlines.

The PROMISE project ran from January 1996 through February 1999. The objective of PROMISE was to provide people with personalized multimodal real-time traveler information throughout their trips. Travelers could access this information at home, in the office, or while traveling. Wireless devices (including mobile phones and PDAs), the Internet, and in-car devices were used primarily to access PROMISE. Based on market research and user-group initiatives, the PROMISE services offered included trip planning, on-trip route guidance, traffic and public transport information, yellow pages, points of interest, and weather information. The following services were available during the project period:

- **Public transport trip planning:** This service allowed trip planning in the Helsinki metropolitan area. World Wide Web and TextWeb services were available. The public transport timetable information included local buses, trams, metros, local trains, and a ferry. The user could perform a web search of local public transport timetables or could type in the origin and destination address and the earliest departure time. The trip-planning service also covered railways, buses, and FinnAir domestic services in the whole of Finland. The Helsinki-Vantaa Airport Flight Information Service gave real-time information on arriving and departing flights at this airport. The user could request an alert, which was sent as an e-mail if the status of flight changed.

TABLE 9 Summary of European cases

Location	System Name/Agency and Description
London, United Kingdom	*Journey Planner*, an Internet-based itinerary planner, and *Countdown*, which provides real-time bus arrival information via at-stop displays, are systems by Transport for London.
Helsinki, Finland	*Personal Mobile Traveler and Traffic Information Service (PROMISE)*: real-time public transport, airline, and weather information available via hand-held wireless terminals and the Internet; a Journey Planner; the Espoo and Länsiväylä Passenger Information System (ELMI): and HELMI, Helsinki City Transport's real-time system covering both bus and tramlines.
Turin, Italy	*Telematics Technologies for Transport and Traffic in Turin (5T)*: public-private partnership to provide public transit information, including itinerary planning, using kiosks, variable message signs, and at-stop displays; also provides traffic and parking-management information.
Magdeburg, Germany	*Personalized Information on Disruptions to Public Transport Exclusive to Users of Public Transport (PIEPSER):* information service that notifies public transport users when there is a delay or a disruption to their selected journey that would prevent them from arriving on time.
Karlsruhe, Germany	*De Orientierte Mensch (DOM):* provides a traveler with an integrated set of travel services that are available throughout the whole trip, from the pre-trip stage through completion of the trip.
Brussels, Belgium	*Phoebus*: real-time information on bus arrival times provided through at-stop displays and real-time bus location on the Internet.
Paris, France	*Aide à l'Intervention Globale sur les Lignes en Exploitation (AIGLE)/ALTAIR, InfoGare/InfoTrain:* variety of initiatives to provide waiting and vehicle departure times and other information via telephone; enquiry offices; and at-stop, in-station, and onboard displays.
Munich, Germany	*BayernInfo*, *INFOTEN*, and *MOBINET*: provide multimodal travel information via personal traveler assistants (PTAs), the Internet, and information terminals.
Bologna, Italy	Various integrated ITS technologies for providing traveler information
Western Europe	Regional ATIS systems that are designed to provide itinerary planning and other transit information via the telephone and Internet. The systems include the OV reisinformatie (OVR) national phone system in the Netherlands; transnational services such as *EFA*, *EU-Spirit*, and *ARISE*; and the United Kingdom's national public transport information system, Traveline.

Figure 48. Transport for London's Journey Planner input page.

Figure 49. *Journey Planner results.*

Figure 50. *London Bus Countdown sign.*

Public transport timetables were also available to people with mobile communicators using the TextWeb service—which is the equivalent of the web service. The service was accessed by sending the TextWeb keyword "bussit"; a TextWeb form requesting the line number was then returned. The same service could also have been used by entering the keyword "transit" or "bussit" together with the line number. PROMISE then returned the answer directly. This service could also be used by sending an SMS to PROMISE. For trip planning, the service was activated by sending the keyword "trip. "After sending "trip," one received a form in which the parameters to be entered were start address (losoite), start municipality (lkunta), destination address (mosoite), and destination municipality (mkunta).

- **Bus stop timetables:** This service gave the next buses at the bus stop. After sending the keyword "bus stops" (pysäkit), the server returned a form requesting the bus stop number. This was a seven-digit number identifying the bus stop. The number normally was on the bus stop. The number could also have been found on the Internet.
- **Weather Service Finland:** This service gave the weather forecast for the next day in major Finnish towns. A search could be performed in two ways: (1) by using the Sonera Textus (TextWeb) "täsmäsää" (weather) service and selecting the town from a menu or (2) by directly entering the town name in the search. The latter allowed the search to be performed using a normal SMS message from a global system for mobile communications (GSM) phone.

Travelers could access the PROMISE service via various terminals. They could use their own PCs for pre-trip planning, or portable communicators for both pre-trip and en route information, or both. The PROMISE system was based on the NOKIA 9000i Communicator as a portable terminal. The device included a full-featured GSM phone; all typical PDA applications; fax; and Internet applications, including a web browser and e-mail.

An extensive evaluation of PROMISE assessed technical performance, user acceptance, and financial and economic issues (*14*). The PROMISE trials proved to be very successful. The majority of user feedback was favorable. About 70% of test users were moderately satisfied or satisfied with the demonstrated PROMISE services and the concept. Services such as public transport planning and intermodal trip planning were considered to be better than other kinds of information sources. The main advantage seen by the test users was that all the information needed for traveling was available in one package and that information could be retrieved whenever needed. On average, users said that they were prepared to pay for the information services at a rate of, on average, 6.5 (US$6.48) per month, or 50¢ per request. Technical performance of the system was relatively good. The users were excited to employ portable terminals for the information services, but the usability of devices required some improvement. Also, mobile access was found to be slow.

The Journey Planner now available from the Helsinki Metropolitan Area Council is shown in Figure 51. It is available (as of December 2002) at pathfinder3.meridian.fi/ytv/eng/.

The Journey Planner allows the user to search for the best public transport connections between an origin and destination using all buses, trams, and metro and commuter trains in the Helsinki region and the ferry to Suomenlinna. The Journey Planner also includes walking connections from the origin to the first stop, at transfer points, and from the last stop to the user's destination.

Helsinki City Transport's real-time system, HELMI, covers both bus and tramlines and was deployed in 2001. ELMI, which is similar to HELMI, provides passengers with real-time information at bus stops and major transfer points in Espoo and Länsiväylä. ELMI is based on a DGPS-based AVL system, with 300 buses equipped on 60 bus routes

Figure 51. Helsinki Metropolitan Area Council Journey Planner.

(see Figure 52). Eleven DMSs and ten video monitors are installed at six bus stops and along bus routes that have stops at the Tapiola Centre and Westend station. DMSs have a 5-inch by 7-inch LED matrix display and are weather and vandal resistant. Each bus route and the waiting time to the next vehicle on that route are displayed on each line of the DMS (see Figure 53). A diamond shape is displayed next to the number of minutes until the next vehicle on the route when the schedule rather than the real-time ETA is being used. The video monitors are 25-in. monitors hung from the ceiling indoors over pedestrian areas, so they are less susceptible to the environment (see Figure 54).

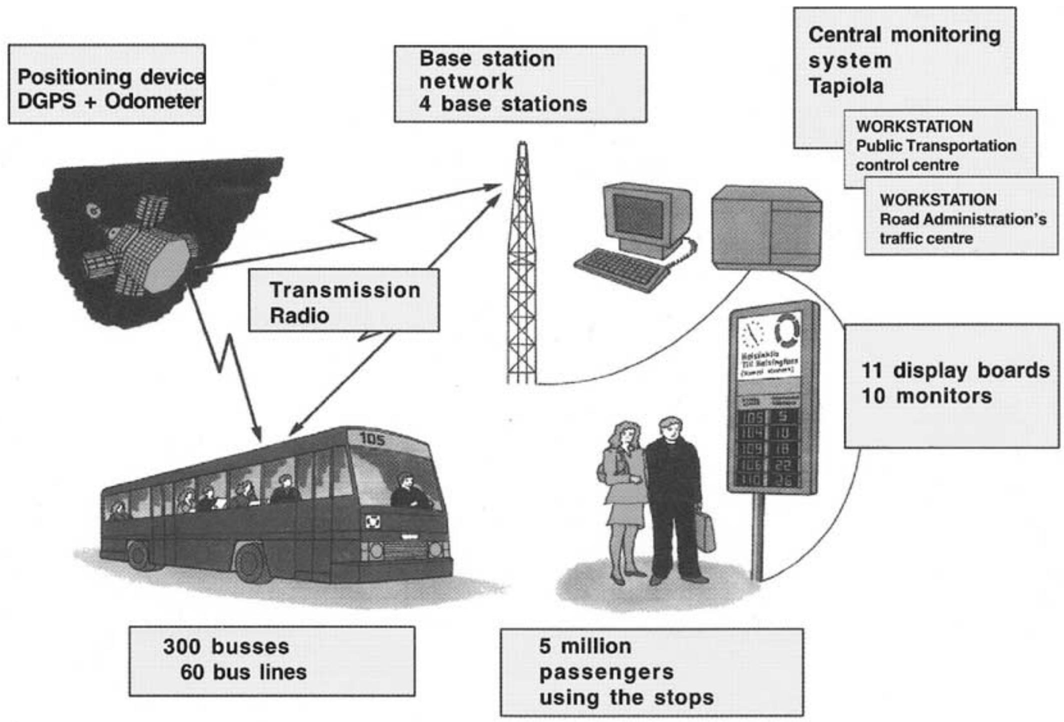


Figure 52. Espoo and Länsiväylä passenger information system (ELMI).

Figure 53. ELMI monitors.

Figure 54. ELMI display boards at bus stops.

5.2.3 Turin, Italy

In 1992, the City of Turin initiated a large-scale ITS project to improve mobility in the urban area. Seven organizations formed a consortium to establish the Telematics Technologies for Transport and Traffic in Turin (5T) program. Specific objectives of the program were to reduce trip travel times by 25% and to reduce emissions and fuel consumption by 18%. The program's trial period ran from March 1996 through December 1997. During the trial, 5T showed the ability to reduce travel times by 21% (equivalent to a 7-minute reduction for each trip). Given the success of the trial, in July 2000, a company called 5T s.c.r.l. was formed in order to design, develop, manage, maintain, and promote the 5T system. The public transport operator, Azienda Torinese Mobilita S.p.A., is a significant partner in 5T.

5T's objectives are as follows:

- Maintain, service, and manage the 5T system and other Telematics applications for mobility in Turin, including the traffic control system;
- Develop and manage the 5T system and other innovative technologies associated with the system in the greater metropolitan area;
- Promote and manage commercial initiatives and services resulting from previous system development activities, with particular attention to the development of fare integration systems and other systems offering public services;
- Design, install, and manage similar systems in other metropolitan areas in Italy and abroad; and
- Participate in research initiatives aimed at the development of the transport Telematics sector.

5T has seven subsystems (*15*):

1. **Town Supervisor** monitors traffic conditions every 5 minutes, forecasts mobility every hour, and checks on the effects of pollution.
2. **Urban Traffic Control** manages the traffic lights by a traffic-responsive regulation and guarantees traffic-light priority to public transport.
3. **Public Transport Management** ensures public transport regularity and speed by means of the Service Information System (SIS), the AVL system. SIS has been in operation since 1994 and is fully integrated with the Urban Traffic Control subsystem to provide signal priority. The Public Transport Management subsystem also provides real-time arrival information via 200 bus stop displays, called VIA (for Visualizzazione Informazioni Arrivi), and onboard audio-visual next stop displays.
4. **Parking Control and Management** is connected to nine automated parking facilities. It forecasts space availability in each facility and enables remote booking by interactive televideo to customers with smartcards.
5. **Environment Monitoring and Control** uses weather forecasts, data from 11 pollution-detection stations, and traffic data to predict environmental conditions in the short term.
6. **Collective Route Guidance** provides dynamic route guidance to various parts of the city by DMSs. It also provides real-time information on parking availability in automated parking facilities. It operates 26 DMSs and 23 parking guidance signs.
7. **TITOS Public Information** provides real-time information on public transport, traffic and parking, and the environment to the Internet and interactive televideo. A new SMS messaging system is being launched for mobile phone users.

The 22-month experimentation phase, which ended in 1997, included observations and evaluations of the subsystems by extensive measurements and interviews and by a telephone survey of a panel of 500 residents. Public transport priority alone led to improvements of 15% for public transport travel times, with no disadvantage to private traffic cross flows.

To illustrate 5T's capability, the Figures 55 through 60 show the journey planning and real-time transit and parking information available on the Internet (www.5t-torino.it/pia-htm/default_en.php, as of December 2002).

5.2.4 Magdeburg, Germany

Personalized Information on Disruptions to Public Transport Exclusive to Users of Public Transport (PIEPSER) is a German project in Magdeburg that is piloting the

> operation of an information service which notifies public transport users when there is a delay or a disruption to their selected journey which therefore would prevent them from arriving on time. As a result, the inconvenience and the effort of the daily retrieval of information in finding out the situation beforehand

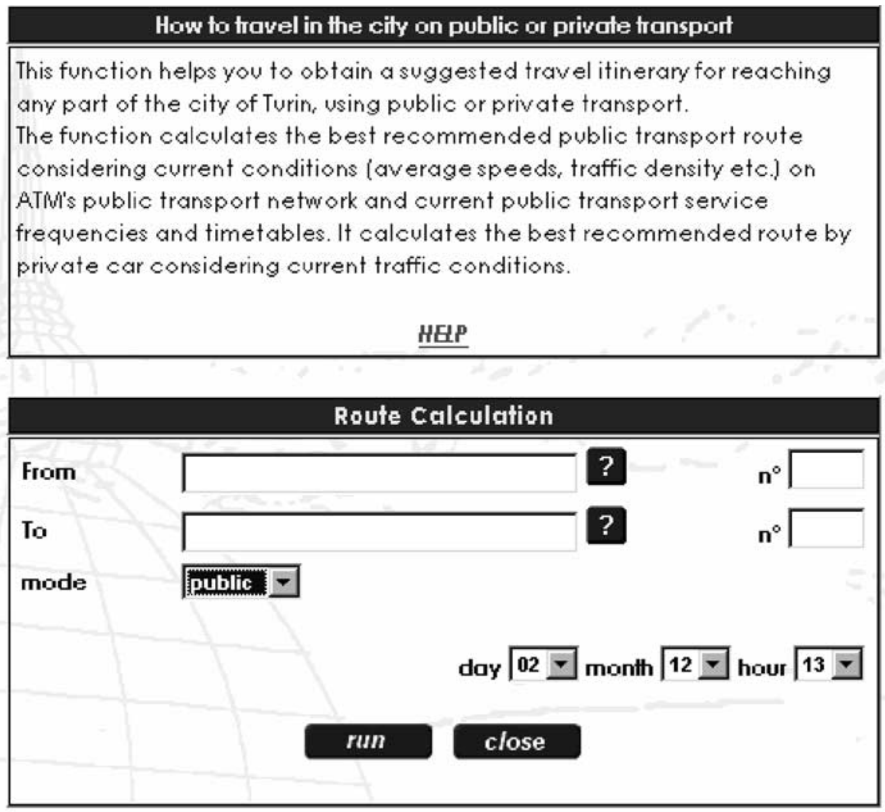


Figure 55. Trip planning using 5T (December 2002).

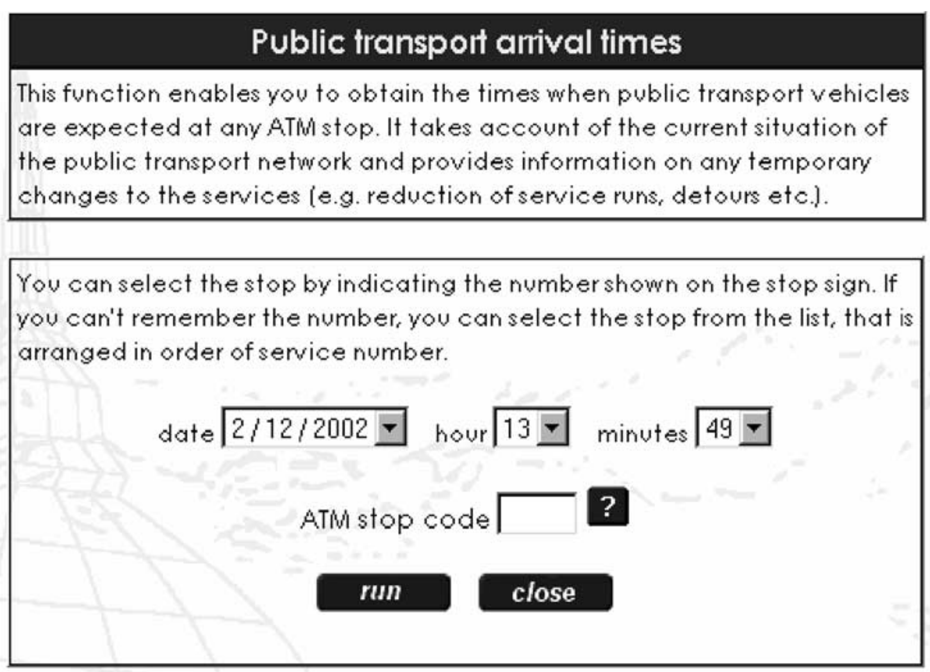


Figure 56. 5T real-time arrival information request.

Figure 57. 5T public transport real-time arrival information by stop.

Figure 58. Real-time parking availability information.

> can be minimized. In addition to the notification of disruption, a multi-modal alternative route will also be provided to the passenger affected, which, depending on the conditions, may still allow the connection to arrive on time. The alternatives of action can be of a spatial, temporary and modal kind. (*16*)

There are several aspects of this project that are unique to most TTI systems, including the following. The system

- Processes and integrates data from several different sources;
- Is only available to customers who purchase monthly transit passes; and
- Uses a standard language for system design and software (Unified Modeling Language).

The distributed system architecture, shown in Table 10, contains six distinct entities that use dynamic and static traveler data: the content owner, content provider, service operator, service provider, network provider, and user. This system, discussed further in Section 8.2, can provide valuable insight into integrating TTI with traveler information.

5.2.5 Karlsruhe, Germany

De Orientierte Mensch (The Oriented Person) (DOM), which was completed in November 2002, demonstrated the capability to provide a traveler with an integrated set of travel services that would be available throughout the whole trip, from the pre-trip stage through completion of the trip. The key concept set forth in this project is the Reisemappe, or travel bag, that contains all of the information collected during the pre-trip phase and is used during the trip (*17*). Another important element of DOM is that all mobile services provided through DOM are location-based so that the customer will receive information specific to his or her location at the time of inquiry.

DOM's features and dissemination media are listed in Table 11. One premium feature of DOM, which not listed in Table 11, is the Delay Manager. This feature

> independently checks previously planned journeys for information which could effect the trip, such as tailbacks or road blocks. The traveler is informed of route-related traffic information before setting off and during the trip. He can react to disruptions, set off earlier, plan alternatives or change the appointment. (*18*)

DOM's services begin with a registered user receiving a Travel Bag, which is used as a repository for information from each service visited (e.g., from those listed in Table 11). All information is saved for use by the traveler as he or she makes his or her trip. A central map, which is employed by all the integrated services, is used by the traveler to identify where the traveler is. Based on that location, specific local services can be offered.

As of December 2002, an extensive evaluation was being carried out. Observed tests were conducted in December

Park name	Location	Price	Service time
D AZEGLIO - GALILEI	C.so Massimo D'Azzeglio - C.so G.Galilei. L'ingresso e l'uscita sono in via Cellini e C.so Galilei.	Feriali L 1.200 dalle ore 8.00 - 20.00 L 800 dalle ore 20.00 - 8.00 Fsetivi L 1.200 dalle ore 0.00 - 24	Dal lun. al sab. 8.00 - 20.00 Dal lunedì al sabato ore 20.00 - 8.00 e giorni festivi orario 0-24

close back

Figure 59. Information about selected parking facility.

2001 and April 2002 in Karlsruhe, Germany. In addition, an Internet survey will be used.

5.2.6 Brussels, Belgium

The Phoebus project focused on three key areas: the public transport database (PTDB), passenger information system (PIS), and demand-responsive system (DRS). PIS provides real-time waiting time information at bus stops and is implemented in the bus network in Brussels. At bus stops, PIS displays three types of information in different fields:

1. The **waiting time field** displays a predefined message with the bus line number and the destination (with routing information if applicable), plus variable data corresponding to the real waiting time in minutes;
2. The **message screen** displays messages that can be predefined in the system or free text messages composed by the operator and received in real-time in ASC II format; and
3. The **date** screen displays the date and time.

The Phoebus pilot scheme for the waiting time information system at bus stops began in 1994, with five bus stop installations in Brussels. As of 1999, two bus lines were fully operational, with high levels of user satisfaction. The Brussels public transport operator (Société des Transports Intercommunaux de Bruxelles [STIB]) was planning to extend the system on its entire network, including the bus and tramway network throughout the Brussels region.

The system displays real-time information on actual waiting times at bus stops. It gives this information only for those buses belonging to the STIB network. Although the tramway network of STIB is currently being integrated in the system, there is no integration with the networks of the two other bus operators active in the Brussels region.

At the terminal points for transit lines, the system also indicates the next departure time exactly. This information is intended for the drivers, to ensure there is no initial delay from the departure point. It is also available to the users to help them choose between buses when two or more buses are waiting at the terminal point, perhaps on different lines. It also provides some social surveillance from the public to any driver who does not leave at the scheduled time. In a later stage, the system will also be used to provide information on intermodal connections between bus lines and the tramway network at crossover points.

The Brussels bus network was equipped in the early 1990s with a Vehicle Scheduling and Control System (VSCS), which was installed to improve real-time monitoring. VSCS's main function is to compare the actual position of the buses with the theoretical position as defined in the timetables. Formerly, the information was used exclusively by the operators in the central control room for regulation purposes. However, without any major modification, the system is also able to compute and predict the expected arrival times of the buses at the different stops. The operating company decided to take advantage of this capability and to provide the information to the passengers waiting at the stops.

The system has been deployed at very low cost due to the fact that the information about the location of the buses was already available in real time in the existing VSCS. Also, the fact that no information transmission infrastructure was needed because of use of existing broadcast networks (use of available radio data system channels) and the provision of a solar power supply makes the system very suitable for any operator who does not want to spend a lot for new infrastructure.

The system has been very well received by the traveling public. Surveys have shown that more than 90% of the passengers look at the information display when arriving at the stop. Of all passengers, 10% stated that they are now using the network more frequently than before as a result of the system. The system has had an important psychological effect, similar to that of the London Countdown system. The researchers' analysis of survey responses suggests that waiting for 10 minutes at a bus stop, but knowing beforehand that it will be 10 minutes, gives the same psychological feeling as waiting for just 3 minutes, but not knowing how long the wait will be. Most passengers felt that the system gives them more confidence in the public transport system. It also gives passengers the opportunity, if the waiting time allows, to run quick errands before boarding the waiting bus. It is not clear if the system pays off or in what period, but it is certain that on the lines equipped with the system, the decline in the number of passenger journeys is much lower than the declines on other lines. In addition to Phoebus, STIB provides bus

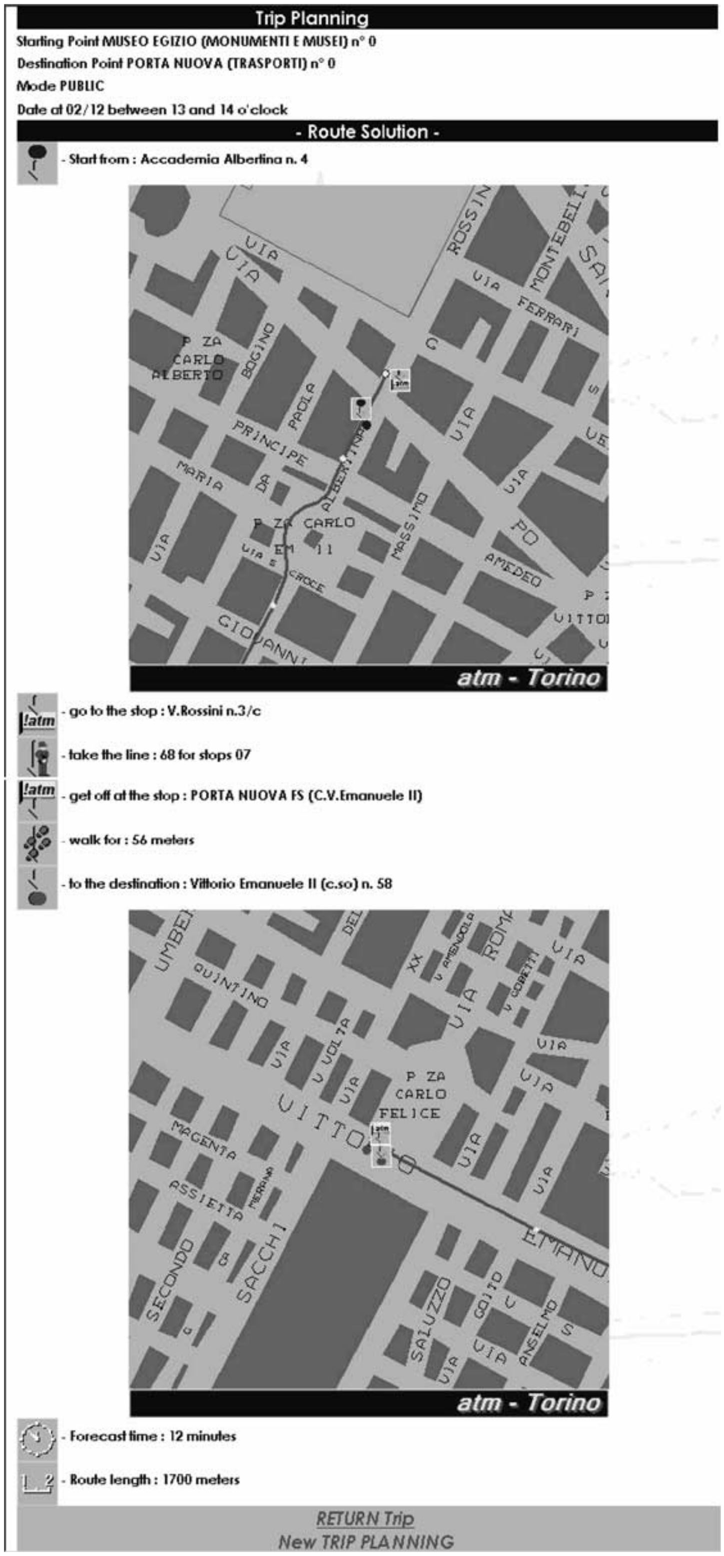


Figure 60. 5T trip plan results.

TABLE 10 Project partners and architecture

Content	Content Owner	Content Provider	Service Operator	Service Provider	Network Provider	User
	Data capture, data processing, data provision	Processing into information, information management, information provision	Processing into service, provision	Service management, customer administration, customer care, service provision	Transport and dissemination	Consume, presentation, requests
Actual departure times of public transport	Local transport company	Local transport company	Local transport company	Local transport company	Operator A Network	Public transport users
Reports on disruptions	Local transport company	Local transport company			Operator B Network	
Timetable of local public transport	Local transport company	Local transport company			Operator C Network	
Timetable of regional transport companies	Regional bus transport companies	Institute of Automation and Communication			Operator D Network	
Actual departure times of regional trains	Central train station management	Local transport company			Landline telephone network	
Timetable of regional trains	Central train station management	Local transport company				
Regular traffic surveillance images	Institute of Automation and Communication, local transport company and city/municipality	Institute of Automation and Communication				
Data on current availability of car parks	City/municipality	Institute of Automation and Communication				
Information on roads under construction	City/municipality	Institute of Automation and Communication				
Data from detectors for road traffic	City/municipality	Institute of Automation and Communication				
Data from detectors of traffic-light control	City/municipality	Institute of Automation and Communication				

(dark grey)	Dynamic public transport data
(light grey)	Static public transport data
(medium grey)	Dynamic traffic data
(very light grey)	Static traffic data

location information on its website (www.stib.irisnet.be/FR/36000F.htm as of December 2002)

5.2.7 Paris, France

In Paris, as in many other European cities, the two major public transport authorities—Régie Autonome des Transports Parisiens (RATP) and Societe Nationale des Chemins de Fer Francais (SNCF)—have deployed new technologies that enable them to enhance the operation of their network and the services offered to customers. The Aide à l'Intervention Globale sur les Lignes en Exploitation (AIGLE) and ALTAIR systems, implemented by RATP, both rely on DGPS-based AVL (*19*). AIGLE provides a security system for both

TABLE 11 DOM features and media dissemination

SERVICE	WEB	WAP	PDA
Travel Bag—checks time context of travel plans and informs user if an event cannot be reached on time with the selected mode(s)/routing; also, saves all pre-trip planning information	X	X	X
Car routing (static and dynamic)—dynamic portion considers historical traffic patterns and current traffic conditions	X	X	X
Public transport routing (intermodal router)	X	X	X
Multimodal router—finds routing and compares travel times and costs across modes	X		
Timetable and stop information—can be personalized for repeat trips	X		X
Personalized traffic congestion information	X	X	
Weather on the roads	X		
Hotel and restaurant guide	X	X	X
Event guide	X	X	
ParkInfo—provides real-time availability of parking spaces; information linked with navigation routing and a map of surrounding area with display of transit stops	X	X	X
Branch guide	X	X	
Personalization	X	X	
Address and appointment manager	X		
News	X	X	
Find-a-Friend		X	
Map service	X		X
Carpool	X	X	

RATP passengers and staff, and ALTAIR provides real-time information on board and at bus stops. ALTAIR is analogous to the Système d'Information en Ligne (SIEL), which provides real-time information on RATP's Regional Rail (RER) service. SNCF implemented the InfoGare system to provide real-time information for travelers in the Île de France. InfoTrain is a project to deliver automated on-board information in the regional trains of the Île de France.

In 1995, after the development of a successful prototype system, RATP started experimental application of ALTAIR on Route 47 (from the Gare du Nord Station to the Kremlin-Bicêtre Station) (*20*). Further demonstrations were conducted in 1997 on additional routes—one bus route and one tram route. Full implementation of ALTAIR began on October 1, 1999, in phases. Phase 1 included the deployment of AVL equipment on 1,500 buses and DMSs at 2,400 bus stops.

The ALTAIR system informs users who are waiting for buses or are making their journeys of the waiting times and destinations for the next two buses. It also informs drivers about their distance and time gaps between the preceding and following buses.

Real-time information on bus times is provided to users in a number of ways via different media. Following a study of the best form of support for this information (French Minitel, Internet, pager, etc.), RATP decided to focus on the telephone. A server delivers voice/audio information about bus stopping times on certain routes. Using the menu, the passenger chooses a bus stop and can receive by phone the same information as that displayed at the bus stop. At bus stops, information is provided about route numbers, final destinations, waiting times, service disruptions, and network information. Up to eight departure times can be displayed, and the information is updated every 25 seconds.

Inside the bus, bus stops are announced and displayed on a running LED sign. The accuracy of the vehicle location is sufficient to trigger announcements without intervention from the driver at any time, synchronized with the arrival at the bus stop, even if the route is changed. Furthermore, the communication network allows the bus to receive service messages sent automatically or by the traffic manager, such as notice of deviations, service cuts, and so on.

The AIGLE system was designed to enhance in-bus safety for both drivers and passengers, enabling a centralized monitoring of bus security and the management of security patrols. In order to operate bus security centrally, buses need to be located precisely, and security has to be monitored. The locations of buses and security patrols are established using the AVL system already described for ALTAIR. Data relevant to security is also monitored in the RATP and police control centers. Alarms and vehicle positions are displayed on a screen. In October 1994, RATP had completed the first phase of vehicle location for security purposes. At the end of 1999, implementation had started, with the goal to equip all buses with security equipment by 2001.

RATP employees also use the Plan d'Information Voyageur Informatisé system, an enquiry office terminal, to answer telephone inquiries from the general public. The system is essentially a reference system that details alternative modes and offers possible itineraries between a given origin and destination. The database encompasses a broad range of information required for trip planning, including the following:

- An interactive network map;
- A list of routes;
- A map of routes to be taken;
- Stops;

- Timetables;
- Addresses, street directories, and main sites;
- Travel times; and
- Tourist information.

The aim of InfoGare, which was developed by SNCF (the national rail operator), was to enhance passenger information at train stations for rail travelers. This project, currently in the demonstration phase, is scheduled for full-scale deployment to the whole Île de France region by 2002 in 350 train stations.

The goals of InfoGare are to

- Provide departure times of trains to travelers via fixed information monitors at the station's entrance and to keep passengers informed about the traffic status at all times (i.e., in normal and abnormal situations);
- Provide passengers with reliable, immediate, and personalized information in every station and on every platform; and
- Inform the station staff simultaneously.

Passengers are kept informed in real time by means of cathode-ray-tube screens set in station buildings and on station platforms. The screens give the following information:

- Time of day,
- Next trains arriving (with their destination indicating codenames of stations to be served),
- The final destination in plain language, and
- The precise time of calling at the station.

The information is supplemented by messages such as "train approaching" or "train delayed," according to the train's actual position. All of the information is continually updated to reflect changing traffic conditions.

InfoTrain, which was planned for deployment in 2001, was supposed to provide audio and visual information on board, including the following:

- Real-time information on the destination and stops;
- Immediate information on the next stop and its multimodal transfer options; and
- Rapid and simple information on service disruptions.

Besides the "technical" information, the passenger would also be informed about the transport products and services available and about offers linked to specific events. Finally, general news, nearby sites of interest, and advertisements would be visually displayed. As of December 2002, the system had not been fully deployed.

RATP has undertaken passenger satisfaction surveys, which indicate that the objectives of both ALTAIR and AIGLE have been achieved. The systems have been repeatedly tested in sometimes very difficult operating conditions, and the information displayed has been shown to be consistently accurate. Measurements have also been taken to check the accuracy of waiting times. These measurements, made in both peak and off-peak periods, were accurate to 30 seconds for waiting times up to 4 minutes and to within 1 minute for waiting times of 10 minutes. This accuracy will, for example, allow passengers to run errands if the waiting time allows or perhaps choose another mode of transport.

Beyond the direct goals of the two systems, the main goal of ALTAIR and AIGLE is to deliver a better quality of service to the user of public transport in two key areas: safety and reliability. The ALTAIR system was also designed after the success of the earlier ALEXIS system, which was used to inform the public.

5.2.8 Munich, Germany

The Munich region—including the city of Munich, which is often referred to as the greater Munich area—has 2.4 million inhabitants with 1.49 million registered vehicles (that is, 0.62 vehicles per capita) and covers over 2,100 square miles. Public transport in Munich comprises 44 miles of subways (i.e., the U-Bahn), 271 miles of rapid transit (i.e., the S-Bahn), 40 miles of light rail, and 2,125 miles of bus routes. On average, rapid transit is used by 700,000 passengers and subways by 800,000 passengers each working day.

The concept of Cooperative Transport Management was developed to contribute to the solution of transport problems in this metropolitan region; the concept solution must accommodate both a medieval city and an industrialized metropolitan area. In the concept of Cooperative Transport Management, administration, industry, and research institutions cooperate to develop strategies and technologies and to carry out assessments of transport ITS systems. The main projects that are relevant to public transport travelers are as follows:

- **BayernInfo** is a large-scale development project for linking multimodal control and information centers to provide a database for traffic information via personal traveler assistants (PTAs) and the Internet.
- **INFOTEN** is a project for multimodal transport information on Trans-European Transport Networks within and between European regions in Austria, Germany, Italy, and Switzerland.
- **Mobilität im Ballungsraum München (MOBINET)** is a €4.5 million large-scale ITS implementation project concerning public transport, traffic management on the arterial roads, information services, and measures to reduce overall transport demand while maintaining sustainable mobility.

Münchner Verkehrs und Tarifverbund (MVV) is the public transport authority in the greater Munich area. The public transport executive for the region is the Bavarian state government. Public transport operators are the Deutsche Bahn AG Railways; the regional bus owners; and the city's subway, bus, and light-rail systems, which are operated by the Stadtwerke Munich (SWM).

BayernInfo has provided the foundation for traveler information services in Munich since 1995. It is a project initiated by Bavaria Online as a part of the Program Offensive for the Future of Bavaria of the Bavarian state government and is being financed by the Free State of Bavaria with approximately 5 million. The project was initially supported by the participating industry partners with 4.5 million.

The aim of the BayernInfo project is to develop a regional traffic information system consisting of a statewide traffic information center and two information centers for the metropolitan areas of Munich and Nuremberg. These centers provide dynamic traffic analyses and forecasts, current traffic situation reports, and timetable information for road users in Bavaria. Additional objectives include Elektronische Fahrplanauskunft (EFA), which provides electronic timetable information; an information system for public transport; and the use of small, portable mobility planners (PTAs) and the Internet for information to travelers before and during their journeys. The development and integration of traffic information centers covering publicly and privately operated services called for new models of cooperation between public transportation departments and private undertakings.

EFA Bavaria provides statewide, door-to-door timetable information on public transport, extending beyond the boundaries of individual systems. The complete timetable is stored for this purpose. From these data, EFA supplies departure times, route information on bus and train transfers, and, in certain cases, fares. The information is provided for the complete door-to-door journey and takes into account temporary traffic restrictions. The information is adapted to customer needs because the system stores a large number of important landmarks and transfer points in the individual transport systems. EFA information is obtainable from the Internet.

BayernInfo provides a platform for dynamic, reliable, and user-oriented travel information with easy user access. For given origin and destination points throughout Bavaria, BayernInfo provides the best route, 24 hours a day. Individual travelers are addressed via the Internet and via handheld mobile PTAs.

The development of an intermodal route planner and the testing of a portable traveler assistant is a major objective. The infrastructure is provided for access to information from the traffic information center and the regional centers in the metropolitan areas of Munich and Nuremberg, as well as from the statewide electronic timetable information. In this way, the portable PTA has access to current traffic information at any time, throughout Europe, via cellular telephone.

The intermodal trip planner is able to search the databases of public transport services and highway networks to provide departure and arrival times for public transport, travel times, and cost comparisons for car and public transport travel. This approach combines current information from the traffic centers and EFA Bavaria for the desired journey and transmits them to the user, together with information on any other transport changes that may be useful to the user. Road users without any local knowledge do not have to plan their routes, and even local users are helped with timetable information for interconnecting public transport systems.

Traffic information from BayernInfo on the Internet is shown in Figure 61. The intermodal travel planner is shown in Figure 62. EFA is shown in Figure 63.

The INFOTEN project conducted from January 1996 to March 1999 introduced language-independent systems for traffic information exchange, multimodal traveler information systems, and advanced driver warning in the Alpine region and in Central Europe.

INFOTEN gives a European dimension to BayernInfo by demonstrating multimodal traveler information systems within and between European regions on the Trans-European Networks (TEN). The information is presented to travelers using a set of multimedia traffic information services that are operated as value-added services. Four devices are available for end-users to receive the information available on the INFOTEN backbone: PTAs, fixed information terminals (FITs), cellular phones, and the Internet. PTAs provide mobile information and allow the end-user to make queries to the INFOTEN backbone. FITs provide the same information on multimodal journeys in Europe, but on permanent terminals that can be found in such places as airports and train stations. Cellular phones can also be used via Austrian and Italian GSM-SMS providers Europewide to receive information. Information is also available using the Internet.

INFOTEN has contributed largely to the technical development of the DATEX specification for interoperable exchange of traffic information between traffic control centers and traffic information centers. Theoretical concepts for multimodal and intermodal information services have been produced that will be integrated into the future European Framework Architecture for ITS.

MOBINET is a project financed by the German Ministry of Education and Technology in the context of the Mobility in Metropolitan Areas Program. This project runs from September 1998 through July 2003 and has 26 partners. Major application areas are new mobility concepts, multimodal transport supply in rural areas, optimization of traffic on the arterial networks, multimedia information services, and linking of traffic information and control centers. As of December 2002, several mobility strategies have been deployed, such as

- Parking-space management in the city center;
- Incident management on rapid transit;
- Dynamic bus service (resulting in an increase in the demand on the rapid-transit railway feeder service by 18%);
- A Bike+Ride facility opening;

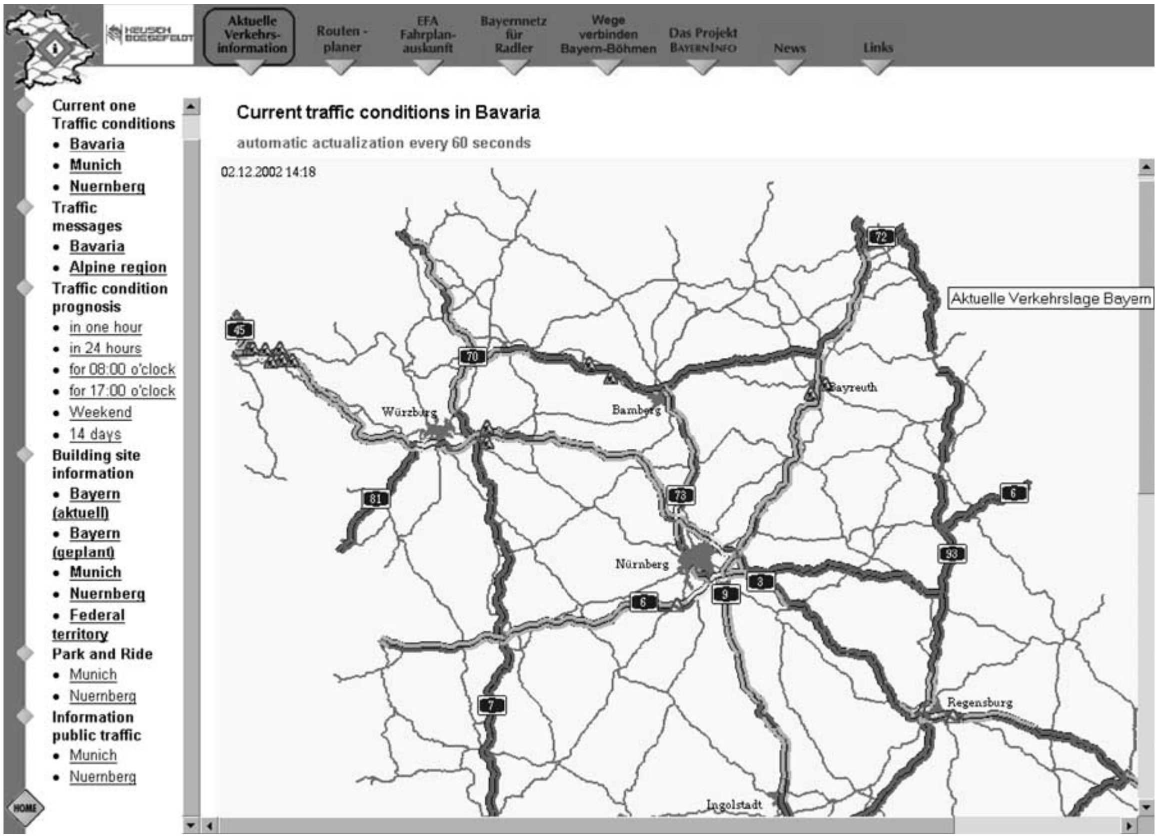


Figure 61. Current traffic conditions from BayernInfo.

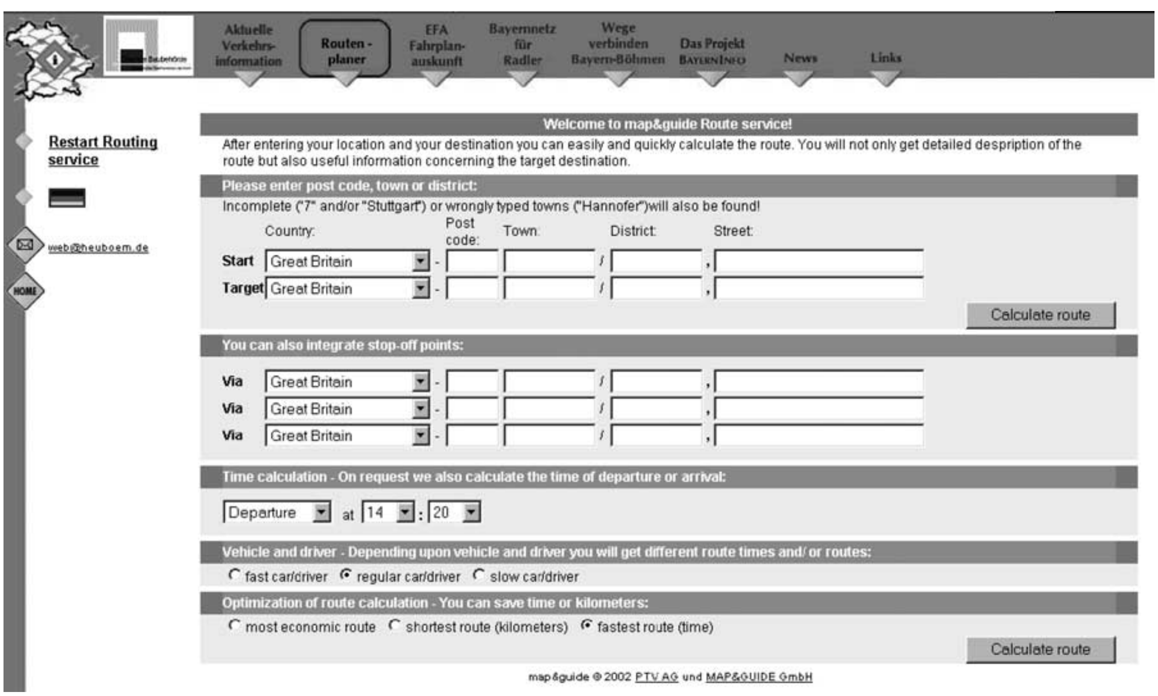


Figure 62. BayernInfo route planner.

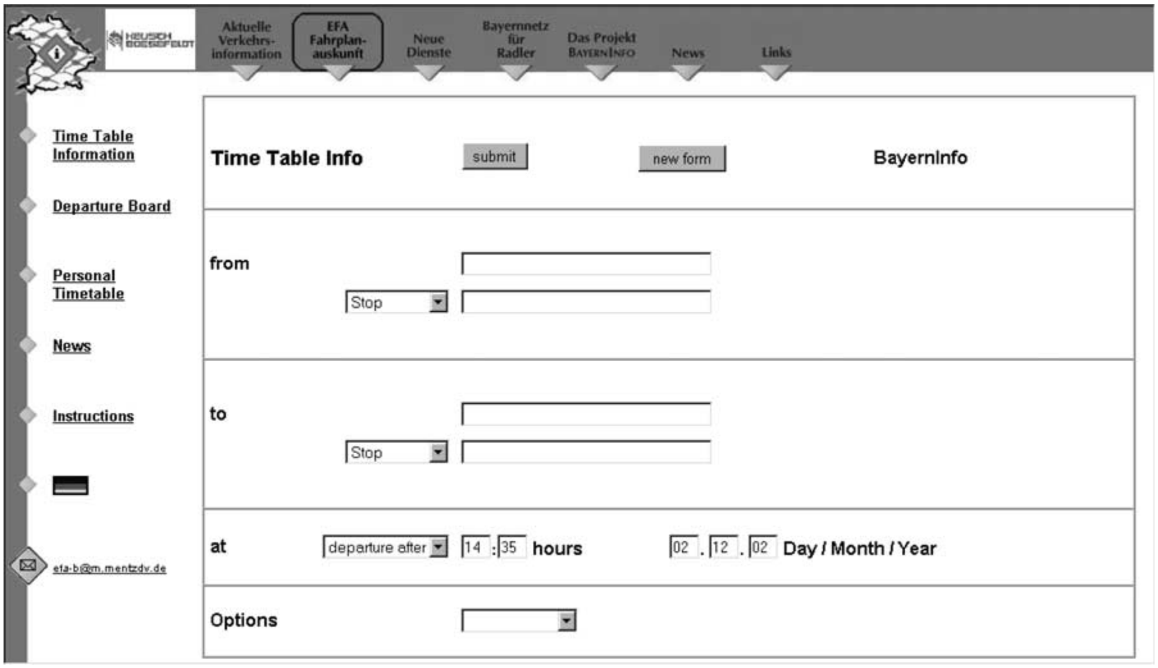


Figure 63. Electronic timetable from BayernInfo.

- Dynamic traffic-control systems deployment;
- Information services such as
  - Net Info, which informs drivers about the traffic situation on the approach roads to Munich;
  - FUNI Info, which integrates traffic and weather information into leisure planning;
  - URBAN Info, which offers Munich city information; and
  - Park Info, which informs users about parking-space allocation and predictive availability;
- Adaptive signals and DMSs; and
- Multimodal information for those with mobility impairments.

So far, several innovative concepts have demonstrated success: 150 teleworkstations have reduced the rush hour, mobility consultation for children (MOBIKIDS) has increased the security of children on the way to school, and 20% to 30% of school children are not brought to school by automobile. The current demonstrations are showing influences in mobility behavior. The evaluations of MOBINET have begun. Building on the success of BayernInfo—which demonstrated that transport ITS applications are accepted by network owners, service operators, and travelers or end-users—MOBINET aims to implement the prototypes and tools developed in some of the earlier projects.

All of the Bavarian and Munich projects discussed are guided by complex evaluation programs to define user requirements and objectives, to assess user acceptance, and to carry out a cost-benefit analysis of the system. For INFOTEN, comprehensive surveys of 1,000 travelers within the regions of the four Alpine countries—Germany, Austria, Switzerland, and Italy—showed a high demand for dynamic information and individualized multimodal information. More than 50% of those interviewed seriously considered changing their planned departure time or route regularly. While only 26% would consider changing mode en route, about 40% could be influenced to change the means of transport in the trip-planning phase.

5.2.9 Bologna, Italy

Azienda Trasporti Consorziali (ATC), the public transport operator in Bologna, is an integral partner in almost all of the ITS projects that have been deployed there. ITS, many systems of which focus on providing TTI, includes the following:

- **Urban traffic control,** which includes integration between private and public transport:

> A special traffic light network was realized which is linked to the buses operative center, [and] special bus lanes have been marked in order to guarantee circulation to buses. The main accesses to the city center are controlled through an automatic system (SIRIO) that detects vehicles approaching the access gate by reading the license plate number. The not-authorized vehicle's image is stored and then forwarded to the control center to be fined. (*21*).

- **Traffic light management,** which uses real-time information to control traffic signals. This system is integrated with ATC's AVL system so that buses receive priority at intersections.

- **Traffic network monitoring,** which includes a traffic-control center that provides real-time information to DMSs installed in various locations in and around Bologna.
- **ATC AVL system,** which monitors all buses.
- **Electronic bus shelters,** which contain DMSs that display real-time arrival information, land-line telephones, ticket-issuing machines, and video surveillance systems.
- **Real-Time Information via GSM mobile phone (hellobus),** which provides the same information as that which is displayed at equipped bus stops. The user selects an SMS message that contains a predefined code that identifies a particular bus stop and route. This message is sent to ATC from the mobile phone provider. ATC then provides the prediction of arrival time for the next bus at that stop on that route in the form of an SMS message back to the user.
- **Demand-responsive public transport,** which uses three types of services:
  - Freebus, which provides route/point deviation service;
  - Videobus, which operates only based on demand (also known as checkpoint service); and
  - Prontobus, which provides service in outlying areas.

5.2.10 Western Europe

Western Europe has regional ATIS systems that are designed to provide itinerary-planning and other transit information via the telephone and Internet. The systems include the OV reisinformatie (OVR) national phone system in the Netherlands; transnational services such as EFA, EU-Spirit, and ARISE; and the United Kingdom's national public transport information system.

5.2.10.1 Dutch OVR: One Phone Number for All Modes

The core activity of the OVR was to offer the Dutch public an integrated travel information service in the Netherlands through one national telephone number. Prior to this program, each public transport company had its own telephone number, and it was difficult to obtain integrated and consistent travel information. There is 1 national rail company, 13 regional bus companies, 9 city bus companies, 4 ferry companies, and 10 other private transport companies.

OVR was deployed in May 1992. Since then, the Dutch have only one telephone number, 0900-9292, to call for public transport information. Available for 18 hours a day (6:00 A.M. through Midnight), for 7 days a week, OVR provides door-to-door information about

- All possible different modes—tram, bus, metro, train, ferry, and so forth;
- Service schedules;
- Fares; and
- Other relevant information.

The timetable information comprises static information about departure, transfer, and arrival times; stops; stations; route numbers; and directions for every form of public transport in the Netherlands. The dynamic information covers temporary changes in timetables such as service disruptions and incidental changes caused by work and events.

The service costs approximately US23¢ a minute, and the average time it takes to get travel advice is 2½ minutes, including waiting time. The costs for the public transport companies stayed at the same level as they were before OVR because the Ministry of Transport supported the initiative financially for the first 4 years, providing 50% of operating costs. OVR installed a national telephone and computer network consisting of 9 call centers with 150 workstations. These are staffed by 400 part-time (20 hours per week) advisors. Since the launch of the OVR service, the number of calls has doubled; during 1992, 0900-9292 handled 5.8 million calls. By 1994, this number had risen to 8.1 million, and by 1997 to 11 million.

5.2.10.2 EFA: Electronic Timetable for Germany, Austria, and Switzerland

EFA, the electronic timetable information system used by about 40 public transport companies in Germany, Austria, and Switzerland, uses a data transmission protocol that was developed and implemented on the Integrated Services Digital Network (ISDN) system. Anyone with a Windows-based PC and an ISDN card can obtain on-line information from every information server. The largest transport operator using EFA is the Verkehrsverbund Rhein-Ruhr (VRR), which covers the region of Ruhrgebiet with about 100,000 trips offered per day.

The EFA user will receive various types of support when inputting departure points and destinations. Instead of the names of stops, one can enter addresses, and EFA will find the closest stop. In addition, there is a search tree for important points in most of the larger German towns. As the precise spelling of the name of a stop or of an address is often not known, EFA uses a phonetic search, seeking to replace unknown names with a valid, but similar sounding, one.

5.2.10.3 EU-Spirit: Seamless Passenger Information Europewide Network

EU-Spirit was a 2-year research project partly funded by the European Commission. Its goal was to develop and demonstrate a customer-friendly, Internet-based, multimodal information system. By using the so called "EU-Spirit travel planning ring," existing and independent transport travel planning systems from several long-distance and local operators will be connected. With the integration of long-distance railway and local transport information systems, EU-Spirit can provide integrated door-to-door public transport information across Europe. This concept is central to the development of future traveler information systems in Europe.

EU-Spirit was set up in 1998 to work toward the above-stated goals. The project lasted 28 months, ending in spring 2001. The consortium comprises 35 partners in 7 countries, representing national and local operators, regions, system developers, and researchers. Deutsche Bahn AG, the German railway company, is leading the consortium as the project coordinator. Initially, the system was demonstrated in a north-south corridor covering Sweden, Denmark, Germany, Austria, and northern Italy. However, in the longer term, the system has the capability to extend coverage to other regions and the potential to cover the whole of Europe, including Eastern Europe.

A key point of the system is that unlike other systems described in this report, EU-Spirit is not a travel planner: the system only compiles information from existing travel planners into a complete door-to-door itinerary. EU-Spirit is only involved in travel planning when a customer not only wants to travel inside a regional transport system or between two main stations, but also needs an itinerary from one local stop to another local stop in another region. EU-Spirit is available at www.eu-spirit.com.

As of December 2002, the following regions or organizations were participating in the system:

- Berlin-Brandenburg,
- Swedish Regional Trains and Buses,
- Scania and southern Sweden,
- Denmark, and
- Emilia Romagna in Italy.

EU-Spirit will develop additional service applications to attract and integrate a wide range of service features. Future services being assessed are as follows:

- Integration of flights, long-distance buses, and ferries;
- Standardization of site information; and
- Fare information and e-payment.

See Figure 64 for the structure of EU-Spirit.

5.2.10.4 ARISE: Dutch, French, and Italian Railway Telephone Enquiry System

Travel schedule information is essential for public transport users if the trains, trams, subways, or buses run at intervals longer than 10 minutes. This information reaches travelers through different media. Telephone enquiries play a crucial role and are now running at more than 200 million calls annually to railway centers in Europe; however, the number of calls that can be handled is limited due to the cost of this human-operated service, with at least 20% of calls going unanswered. ARISE aims to improve this situation by handling the bulk of routine telephone enquiries automatically, thus freeing the operator for more complex and higher-valued services. The project is backed by strong demand from public transit operators.

The Dutch, French and Italian railway operators want to enhance the quality of their services, and easy access to timely

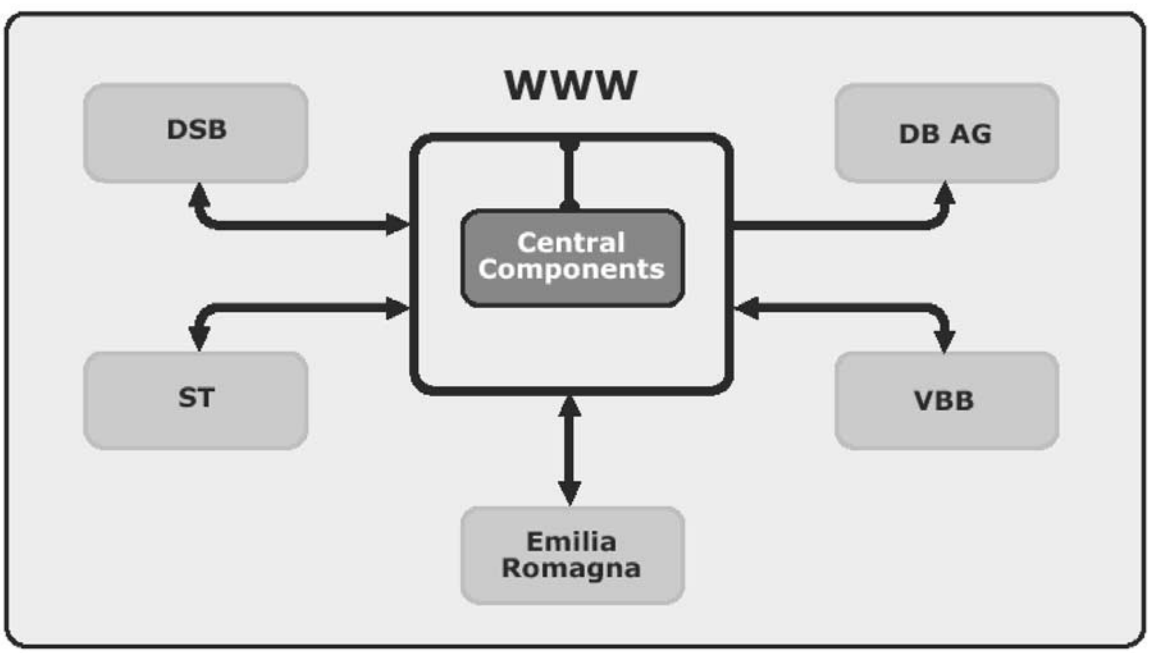


Figure 64. EU-Spirit general system structure.

and accurate information about schedules and travel options is considered essential. With this intention, the railway operators have already had a number of telephone enquiry systems installed that are manually operated or that use dual-tone multifrequency (DTMF) technology. However, due to cost and a need for easier accessibility, the routine operations need to be fully automated.

Today, speech recognition is at a crucial turning point: it is moving from a situation of technology push to demand pull. The ARISE projects reflect this shift in organizational terms, and the research focuses on more pragmatic viewpoints. In principle the market prospects appear large since many call-center operations can be usefully supported by the technology. One of the key questions that ARISE is hoping to address is whether transit customers will be willing to accept the technology and to talk to a machine.

ARISE operates in three language environments—Dutch, French, and Italian—each bringing together a service provider, technology providers, and system integrators. In the Netherlands, the railroad operator has commuter traffic mainly in two relatively short periods of the day and has a need to increase off-peak traffic by providing timely information for the casual traveler. A subsidiary company handles more than 11 million calls annually, using 400 operators. Sixty percent of these calls require information concerning more than one public transport service. One of the technology providers was a pioneer in voice recognition technology and now has 20 years of experience with that technology. The provider has achieved an 80% success rate for a German train schedule enquiry system that has been operational since February 1994.

In France, the railroad operator has 1,300 staff to answer more than 40 million telephone calls for train information each year. It has extensive experience with public information systems over the telephone network, especially dialogue systems. One of the technology providers has a spoken language processing group that specializes in speech analysis and synthesis. The university partner has experience in automatic speech processing, mainly in phonology, lexica, and analysis of speech corpora. The two system integrators have particular experience in speech recognition and synthesis and in public transport information systems.

In Italy, the railroad operator deals with over 20 million telephone requests annually. One of the technology providers has focused research on speech recognition in adverse environments. The system integrator has already supplied a videotext train timetable and has much experience in on-line services.

The main goal for ARISE is to develop an automatic train schedule information system that can communicate verbally via the telephone. Other goals include the following:

- A system that is easy for the public to use;
- A high level of satisfaction for the caller;
- A level of quality that is comparable with human-operated systems;
- The ability to work as part of a full-blown, human-operated service that provides door-to-door information, especially for the Dutch transport system;
- Greater revenue from the information.

Specific objectives vary according to the requirements within each environment.

5.2.10.5 *United Kingdom: National Public Transport Information System*

The British Government wanted to see greater integration between different transport modes so that people could "mix and match" their travel mode choices according to their particular circumstances. Part of the initiative for a national public transportation information system was to deploy a traveler information system that allows people to find information on any public transport services in the country. Information would be available nationally via a common access point: a telephone enquiry point with a number that is easily memorized. The same information would be available to public transit enquiry bureaus and to the public on TV teletext and on the Internet. This telephone enquiry system has been deployed and is called Traveline. The national phone number for Traveline is 0870 608 2 608.

A national partnership among the bus operators, the local transportation authorities, and users' representatives was established for the delivery of this project. A steering group chaired by the Confederation of Passenger Transport (representing bus, coach, and light rail operators) developed the project plan. The plan is complemented by local Public Transport Information (PTI) partnerships in each region.

The initial focus of the plan was to make comprehensive timetable information available for local, regional, and national services—the equivalent of a "roadmap" of transit services—detailing the entire public transit network. There are plans to add fare information at a later stage. The implementation strategy builds on information services that are already up and running. There is, for example, already a national timetable enquiry service for the passenger railroads. Nothing similar exists for the local bus networks and rail systems, although some county councils have established their own Internet sites. The local PTI partnerships are being asked to fill in the gaps. Legislation is being considered to make it a duty of local authorities to secure the availability of transit information for their area with cost recovery from the operators. In effect, the national public transit information system is a federal system that is being constructed from the bottom up.

One website currently provides information on all public transport in the United Kingdom, but it is not integrated. See Figure 65 for an image of this website (www.pti.org.uk/).

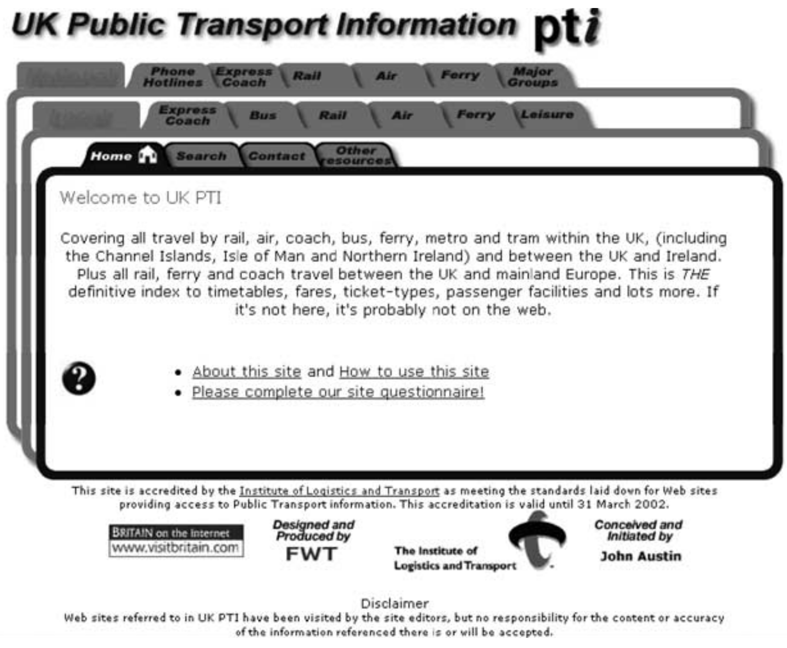


Figure 65. UK website for public transport information.

Local PTI partnerships brought together information on local journeys for all modes, with trunk journeys to and from the area in Traveline. Traveline includes a variety of access media and common standards of service. The added value of the project is that it draws together information from a large number of different sources.

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10. www.baruch.cuny.edu/ccvip/background_kiosk.html and www.baruch.cuny.edu/ccvip/kiosk.html (as of December 2002).
11. Baruch College Computer Center for Visually Impaired People. Reported in *Advanced Public Transportation Systems: The State of the Art Update '98.*
12. Visit the MTC homepage at www.mtc.ca.gov/ and the TravInfo homepage at www.travinfo.org/.
13. Initially, the expectation was to equip 6,500 buses with AVL. However, with the increase in ridership and amount of service provided in 2002, the current projection is that a total of 8,000 buses will be equipped with AVL. It is also expected that this figure may increase again once the Congestion Charging Scheme goes into effect in February 2003. This somewhat reduces the 80% complete figure for AVL.
14. Ojala, T., P. Green, I. Bonner, and E. Bastiaensen. *PROMISE—Personal Mobile Traveller and Traffic Information Service,* Final Evaluation Report, Deliverable D7.4, Version 2.0, Project Number TR1043, January 13, 1999.
15. www.5t-torino.it/consorzio_en.html (as of December 2002).
16. Hoyer, R., and O. Czogalla. "Approach to Personalised Information Services to Public Transport," *Proceedings of the 9th World Congress on ITS,* Chicago, Illinois, October 14–17, 2002; pp. 1–2.
17. Esters, D. "DOM—Der Orientierte Mensch (The Oriented Person): The Requirements and Development of Mobility-Oriented Internet Services," *Proceedings of the 9th World Congress on ITS,* Chicago, Illinois, October 14–17, 2002.
18. Ibid., p. 7.
19. DGPS was used because of the urban environment in Paris and the fact that selective availability was still being used in the GPS system at the time that these systems were being demonstrated.
20. "RATP. Siel, mon bus!," *La Vie du Rail,* December 20, 2000.
21. Description of ITS systems in Bologna provided by ATC S.p.A. Trasporti Pubblici Bologna, May 8, 2002.

SECTION **6**

SUMMARY OF EXAMPLES FROM OTHER INDUSTRIES

The provision of customer information is not confined to the transit industry. Other industries such as airlines and package delivery services provide time-sensitive customer information. Several nontransit businesses were assessed to learn how they provide customer information and what technologies they use to provide the information. Unfortunately, most of the businesses contacted were reluctant to discuss their current or upcoming systems. The industries investigated include package delivery services, airlines, and wireless content providers.

6.1 PACKAGE DELIVERY SERVICES

6.1.1 United Parcel Service

United Parcel Service (UPS) tracks the location of packages by scanning bar codes on packages each time packages arrive or leave a facility. UPS is able to track between 13 and 15 million packages a day. The evolution of its current tracking system began in the early 1990s when UPS was providing tracking services to corporations. Corporations had a direct link to UPS that enabled them to track their packages. By the late 90s, UPS was offering "real-time" tracking on the Internet allowing all customers, whether corporations or individuals, to have the same access that was once limited to corporations only. In 1999, UPS started providing wireless "real-time" tracking for PDA users.

The decision to provide wireless tracking services was not actually based on research or studies. The decision was made by senior management, who wanted UPS to move forward and to stay current with wireless communication technology. UPS projected that there would be financial benefits for providing wireless services. UPS had determined that tracking through the Internet was reducing costs: each Internet inquiry meant one less 1-800-number call charge for UPS. Hence, going wireless would further reduce UPS's 1-800-number call charges.

UPS's Track application allows the user to track up to 25 packages at the same time. The user is prompted to enter the tracking number of his or her packages, and the system then displays the current status of the packages. The user has the option to request more detailed information, such as when the package arrived at and left various facilities en route to its destination (see Figure 66).

UPS is always in the process of improving its infrastructure. Its plans are to improve the estimated arrival time of packages from the current 24 hours down to perhaps ½ hour. Also, UPS has a premium (for fee) service for corporations in which a number of functions and services are bundled together. There is a charge for this service because it provides detailed information on packages and has the ability to produce reports. UPS states that there was resistance to pay for the premium service because subscribers believed that the service should be covered by the shipping costs; however, UPS is not aware if customers' attitude toward paying for premium service changed after using the service.

6.1.2 Federal Express

Another package delivery company that provides detailed tracking information to any user is Federal Express (FedEx). FedEx offers two tracking services. The first is FedEx Track, which is similar to UPS's service in which customers are able to track up to 25 packages via the Internet. FedEx's Track application provides a detailed description of the package's location throughout the package's entire trip. The second tracking service offered by FedEx is FedEx InSight℠.

InSight not only tracks inbound, outbound, and third-party payer shipments, but it also automatically notifies the customer of critical shipping events so that the customer can take the necessary action. Notification of these events can be by e-mail, fax, the Internet, or wireless devices. InSight provides status summaries of international and domestic shipments on one report because tracking is based on addresses or account numbers—not on individual tracking numbers. Furthermore, InSight helps pinpoint customs delays and delivery attempts then suggests recommended actions to expedite delivery. Both tracking services are offered to FedEx customers at no charge. Figures 67 and 68 show examples of FedEx InSight.

6.2 AIRLINE NOTIFICATION SERVICES

Airlines continue to invest in technology that automates interactions with customers; this strategy has drawbacks, but it also has benefits for the public. An example of such a

Figure 66. UPS shipping information.

promising automation technology is the flight-status notification services that are offered by most major United States carriers. The details and sophistication of the services vary by airline, but the basic function is the same: it allows customers to sign up for automatic notification on arrival and departure times, including information about delays, gate changes, and, sometimes, where baggage can be retrieved (*1*).

Currently, American, Continental, Delta, Northwest, and United Airlines and Travelocity, Orbitz, and Expedia provide flight notification information to a variety of land-line and wireless devices that can receive e-mail or text messages. United's EasyUpdate service (www.ual.com/easyupdate) offers more features than do the other airlines' services, including quiet times when the user does not want to receive any message (e.g., on a home phone between 11 P.M. and 6 A.M.); notification about seat upgrades; and registration for all flights, not for each individual trip. See Figures 69 and 70 for United's service and Figure 71 for American's Flight Status Notification system.

The one drawback to these notification systems is the timeframe within which the airline will send delay notifications. By the time a delay message is sent, the user may have already left for the airport. Also, even if a flight is delayed, the airline may suggest that the user still go to the airport in case the status of the flight changes.

6.3 WIRELESS CONTENT PROVIDERS

6.3.1 Location-Based Advertising

Several companies are now providing advertising and coupons to wireless PDAs and mobile phones based on the devices' locations. The following describes two location-based content services that take advantage of locating these devices (*2*):

- **Vindigo** provides location-based services in 35 markets in the United States. Free software that is downloaded to PDAs by registered users provides location services, such as directions to local shopping, restaurants, and entertainment. The PDA's location is combined with information on what the user is searching for to send targeted ads and coupons to the user. So, if the user is searching for a movie theater in a particular neighborhood, a coupon discounting the movies in that theater could be provided to the PDA or cell phone user along with directions to the theater.
- **go2Systems** provides location-based information by partnerships with major cellular providers. It provides web portals, such as go2hotels.com and go2jiffy.com. Web-enabled phones, PDAs and Blackberry RIM devices can be used to access go2Systems location-based ser-

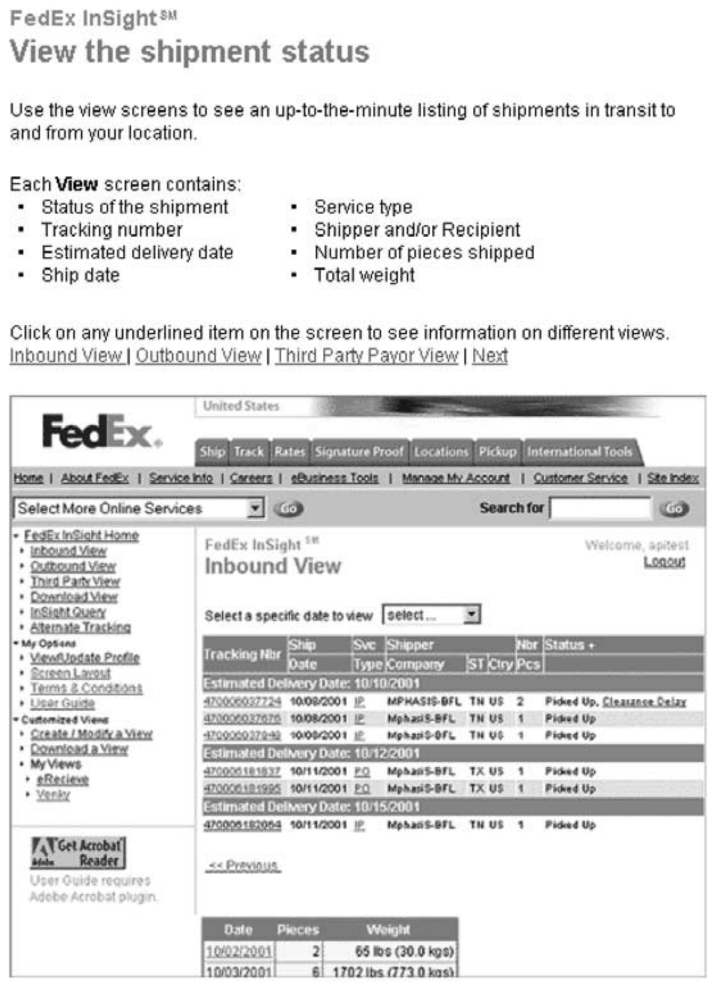


Figure 67. FedEx InSight screen.

vices. If the user enters "Jiffy Lube," the go2System will provide the location closest to where the wireless device is being operated.

6.3.2 Wireless Local Area Networks

High-speed wireless local area networks (WLANs) are becoming commonplace throughout the world as an easy way of "staying connected." Airline clubs, hotels, and many other businesses are taking advantage of WLANs to provide their customers with Internet and e-mail services away from the office or at home. The wireless Ethernet standard, 802.11b, is being used to provide WLAN services. One commercial version of this standard, called WiFi, is making it possible for consumers to purchase consumer and food items using their mobile phones (*3*): "If you would like to check your corporate e-mail while sipping a fresh cup of Decaf Mocha Java, you're probably already a user of MobileStar's public access points found in 350 Starbucks Coffee locations now and scheduled for 4,000 of the shops by summer's end" (*4*). The approximate charge for this type of wireless access is $15.95 per month (200 minutes) or 20¢ per minute.

6.3.3 Zero-Sixty

While this company does not provide wireless services per se to the transit industry, Zero-Sixty provides transit riders with bus and train schedules specially formatted for PDAs. Zero-Sixty buys the schedules from transit agencies, packages the data, and, in turn, sells the data to its customers. Zero-Sixty receives the schedules from the transit agencies in a spreadsheet format a week in advance of a schedule change. The schedules are re-packaged and e-mailed to the customers. The customers then download the schedules to their PDAs. Customers pay $12 per schedule per year. Zero-Sixty also offers bundled services (access to more than one schedule) for an annual fee of $34.95.

The transit schedule application was developed in January 2002 and started operating in April 2002 for the Metro-North and Long Island railroads. Zero-Sixty plans to provide

Figure 68. FedEx InSight screen.

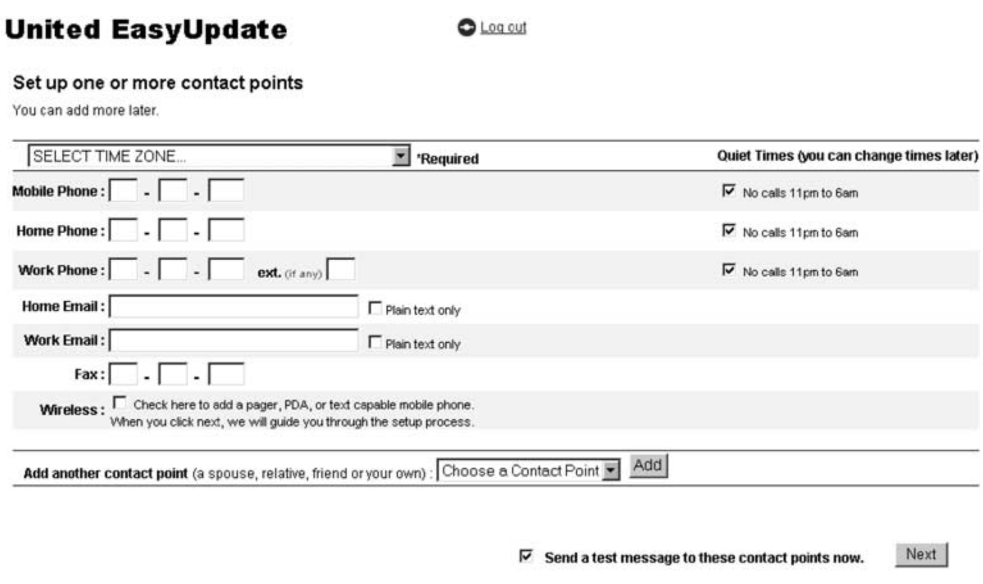


Figure 69. United Airlines EasyUpdate contact information.

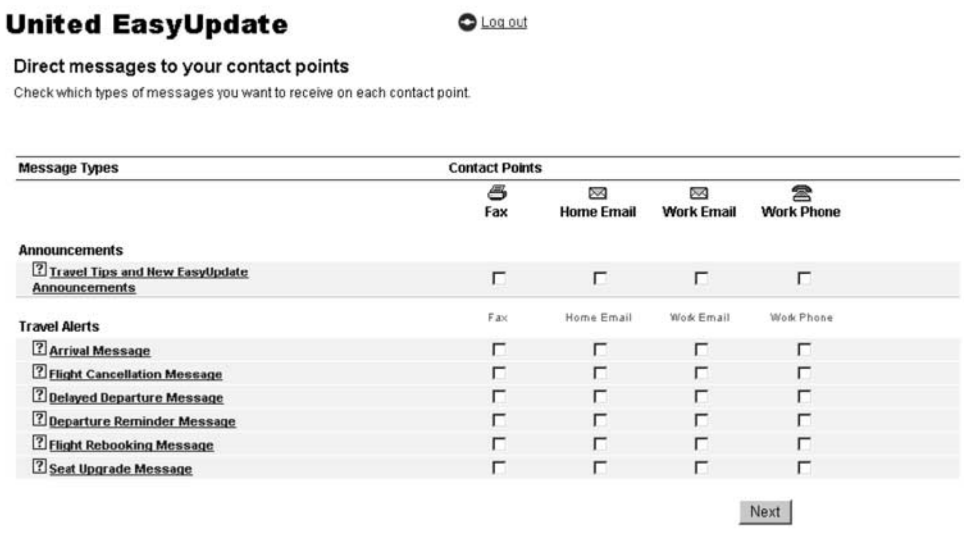


Figure 70. United Airlines EasyUpdate message types and contact selection.

via wireless media actual estimated arrival times once there is a standard platform for the handheld devices. It currently has 600 commuter rail and 300 subway subscribers to the service, which started in June 2002. Zero-Sixty's goal is to have 10,000 subscribers by mid-2003.

Zero-Sixty indicated that overall feedback from customers has been positive. Zero-Sixty's future plans include providing the following:

- More station information such as fare, location, and routes or lines serving particular stations;
- Maps;
- Actual arrival times;
- Alerts of delays; and
- Alerts of a train being *X* minutes away from a customer's intended boarding location (this feature is currently under development).

6.3.4 Second Kiss Wireless

Second Kiss Wireless' product, ShuttleGirl™, is a commercially available platform for wireless and portable transit schedules and delivers information to travelers and commuters via web browsers, handheld devices, Internet-enabled mobile phones, and traditional telephones. As of December 2002, schedules are available for Amtrak's Acela and Metroliner services; GO Transit's Stouffville GO Train and Bus Service (in Toronto, Canada); Harvard University Shuttle Services; LIRR's Port Washington Branch; Massachusetts Bay Transportation Authority's Commuter Rail Service; Metra's Electric Line (in the Chicago area); Southeastern Pennsylvania Transportation Authority (SEPTA) Regional Rail R5 and R7 Lines; and Tri-County Commuter Rail Authority's South Florida Rail Corridor service.

6.3.5 Weather Channel

The Weather Channel has two wireless services: MyWeather and Notify! MyWeather provides weather information and alerts for a particular area selected by the user. Information such as severe weather watches and warnings is transmitted to PDAs, cell phones, e-mail, or to a combination thereof. There is no charge for MyWeather.

Notify! allows users to get their choice of weather alerts, to select how to receive the alerts, and to select when they want to receive them (see Figures 72 through 74). The user can select the type of weather that is his or her concern (e.g., rain, snow, tornados, etc.); the severity of the condition; how to be notified (i.e., by phone, PDA, fax, or e-mail); and when to be notified. For example, when a tornado warning is issued at 3:00 A.M. in the user's area, Notify! will call his or her home phone so that he or she can take action for his or her family. One feature of Notify! is the capability to select a "quiet" time period, in which the user does not want to receive any notifications (see Figure 72). Notify! is a free service. Notify! Plus is also available for a charge. Features of this service are shown in Figure 75.

The Weather Channel has recently come out with a new application called Desktop Weather. This new application provides current temperature continuously updated in the user's system tray; severe weather alerts that can be seen and heard; complete current weather conditions; local radar maps; and 12-hour forecasts. A subscription to Desktop Weather is $3.99 per month or $29.99 per year.

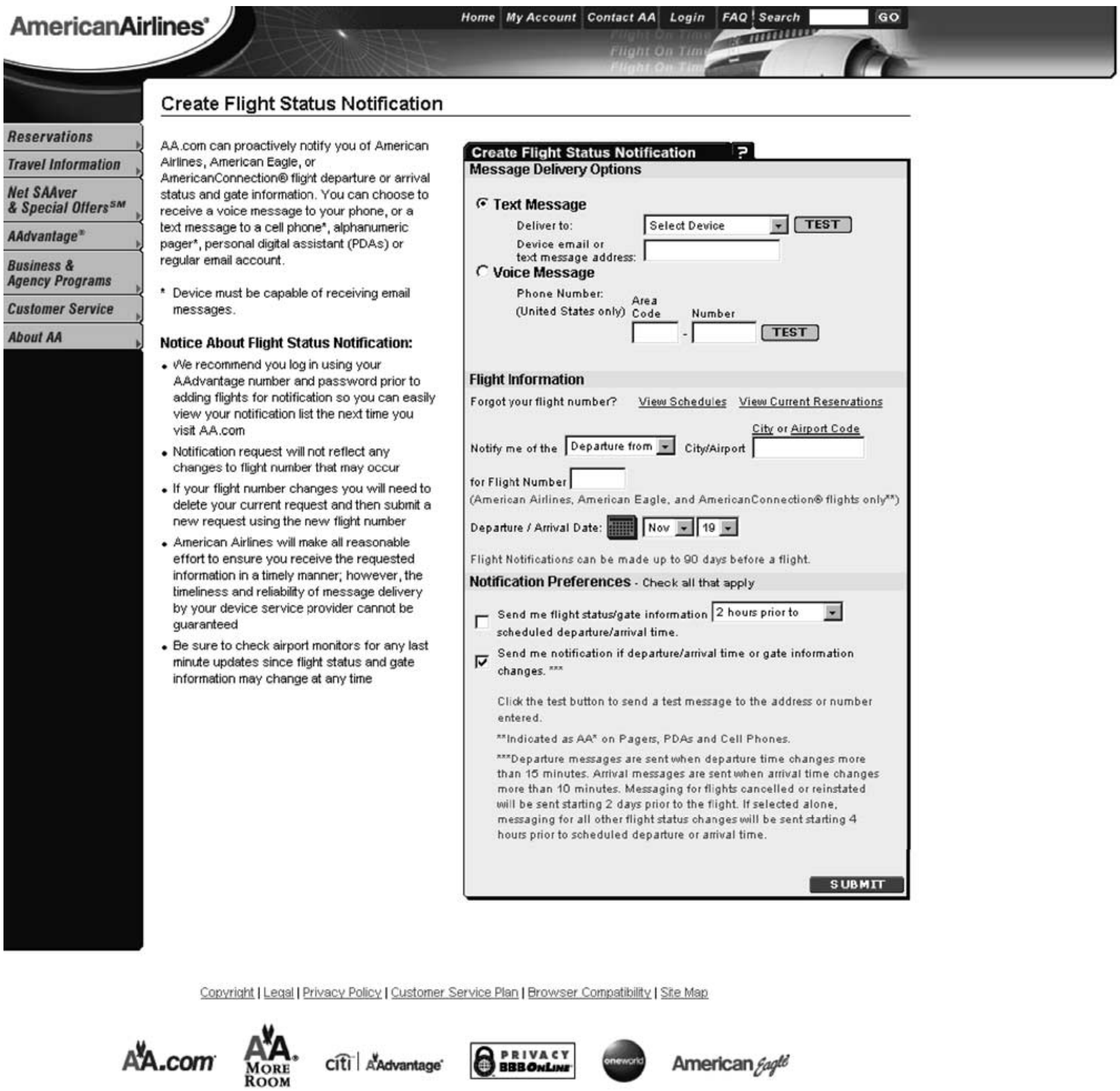
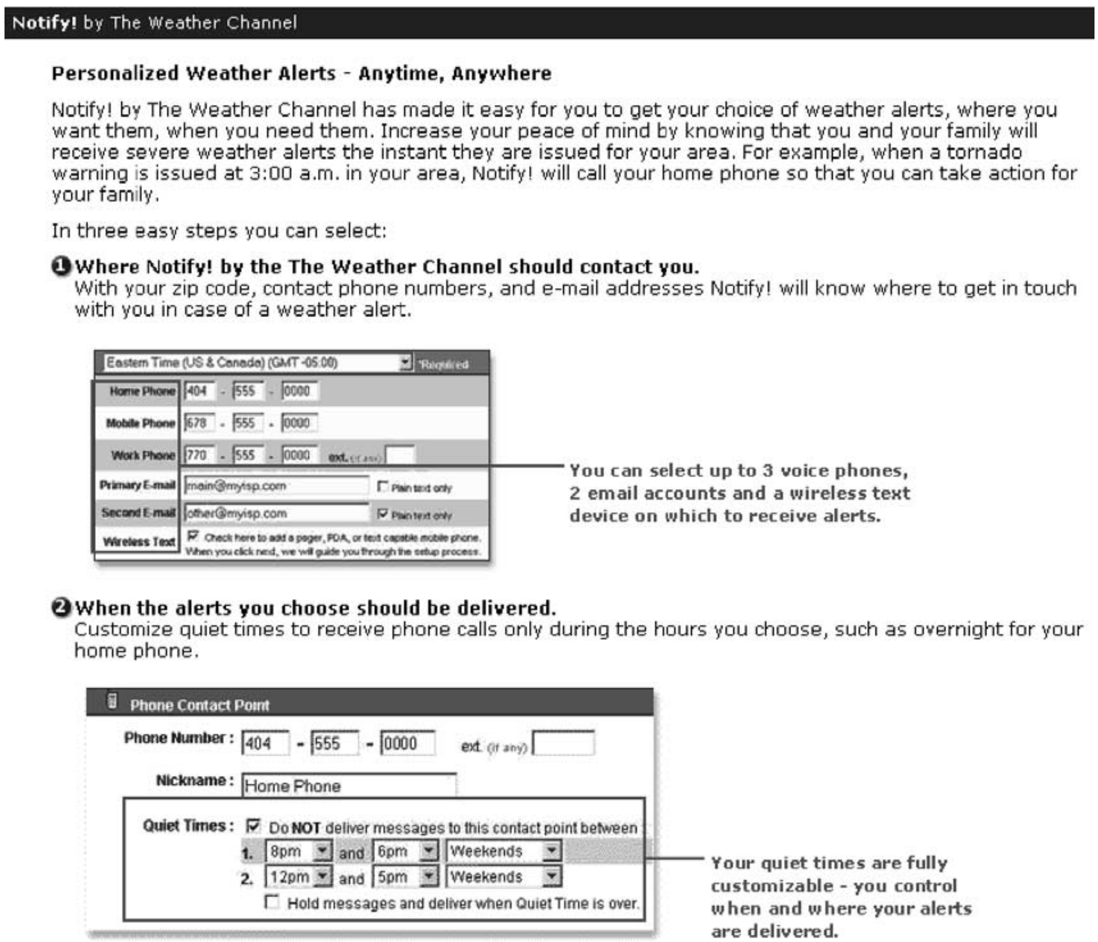


Figure 71. American Airlines notification registration.



Notify! by The Weather Channel

Personalized Weather Alerts - Anytime, Anywhere

Notify! by The Weather Channel has made it easy for you to get your choice of weather alerts, where you want them, when you need them. Increase your peace of mind by knowing that you and your family will receive severe weather alerts the instant they are issued for your area. For example, when a tornado warning is issued at 3:00 a.m. in your area, Notify! will call your home phone so that you can take action for your family.

In three easy steps you can select:

❶ Where Notify! by the The Weather Channel should contact you.
With your zip code, contact phone numbers, and e-mail addresses Notify! will know where to get in touch with you in case of a weather alert.

❷ When the alerts you choose should be delivered.
Customize quiet times to receive phone calls only during the hours you choose, such as overnight for your home phone.

Figure 72. Notify! contact information.

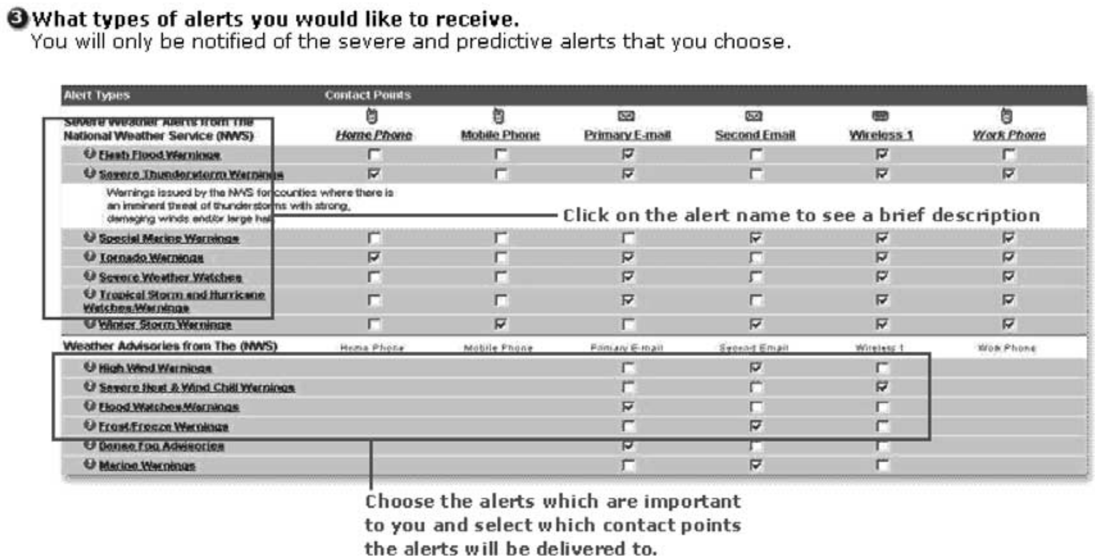


Figure 73. Notify! alert features.

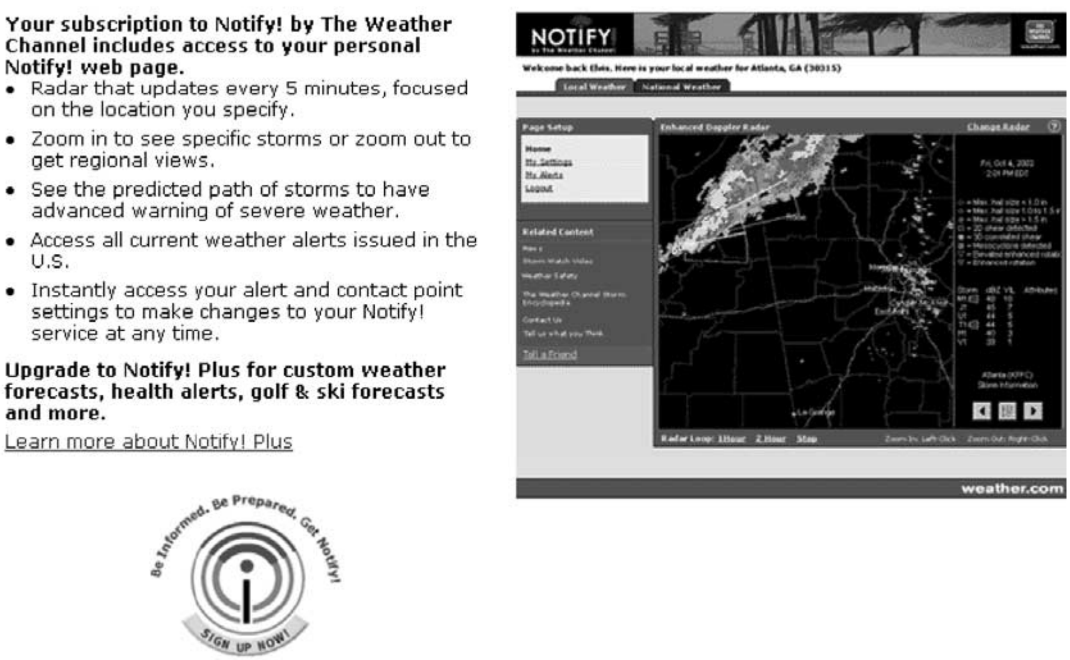


Figure 74. Personal Notify! features.

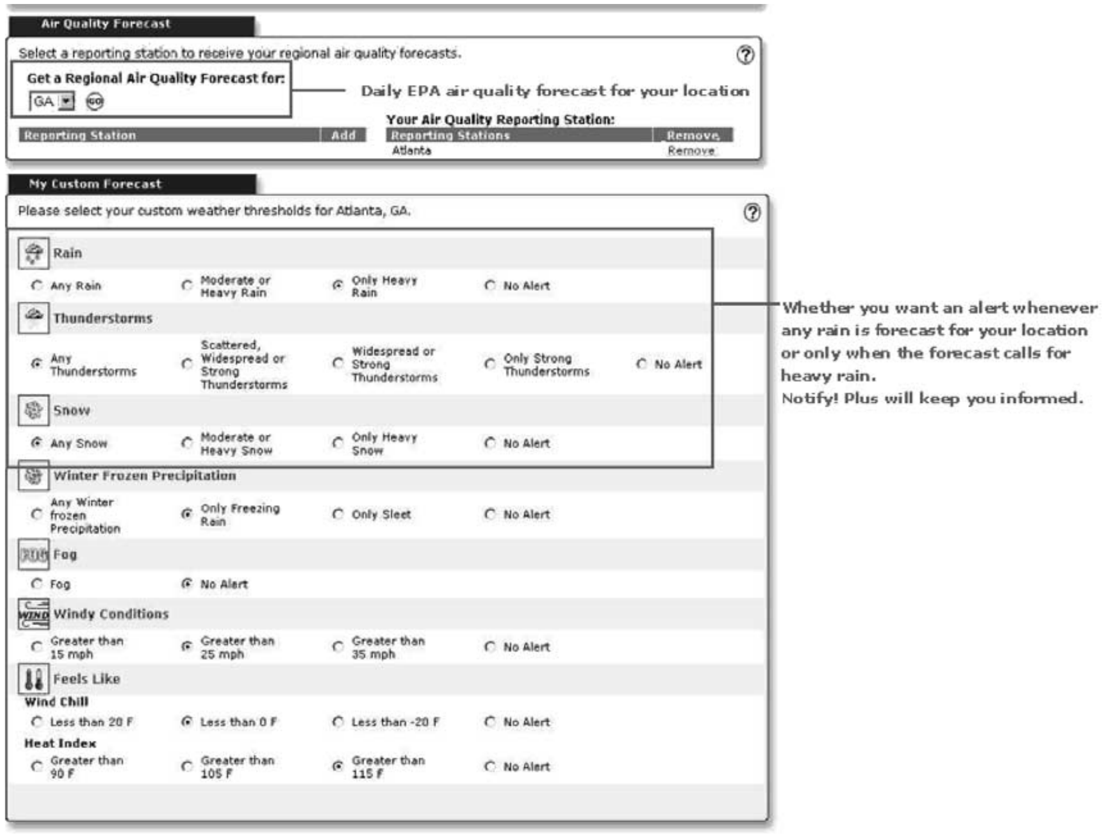


Figure 75. Notify! Plus features.

6.4 REFERENCES AND ENDNOTES FOR SECTION 6

1. Stellin, S. Paraphrased from "Flight Delayed? Find Out Fast," *The New York Times*, Sunday Travel Section; December 1, 2002.
2. Sutherland, E. "Location-based Ads in the Real World," *M-Commerce Times* (www.mcommercetimes.com); January 2, 2001.
3. "Wirca Launches Pay-by-Phone Software in Schlotzsky's Delis," *M-Commerce Times* (www.mcommercetimes.com); November 26, 2002.
4. Sutherland, E. "Would You Like a WLAN Card with Your Frappuccino, Sir?," *M-Commerce Times* (www.mcommercetimes.com); August 2, 2001.

SECTION **7**

TTI AS PART OF A COMMUNITY INFORMATION SYSTEM

An increasing number of metropolitan areas are developing regional ATIS and 511 systems (*1*), which are responsible for disseminating traffic and travel information by telephone, websites, or other means. Transit agencies are frequently partners in these systems, and TTI information that the transit system generates to inform existing and potential passengers is contributed to the regional pool of data used to make travel decisions.

The most common form of participation in regional ATIS so far has been to provide links to a transit agency's standalone information resources. Often, a regional ATIS website will provide live links to the websites of the area's transit and paratransit service providers and to a regional telephone service that transfers callers to a transit system's telephone information system. More and more often, North American transit agencies are providing real-time service information, itinerary planning, or both; some integration of the transit information with information about other travel alternatives is becoming more than just a desire: from the customers' perspective, it is becoming a necessity.

Because public transportation content is considered a key content category, transit participation in the 511 system has been growing since the system's inception in 2000. For example, the 511 systems deployed in the San Francisco Bay Area and in Utah contain significant transit content. In the next section, (Section 7.1), information pertaining to transit's participation in the 511 system is presented, using UTA as an example.

In a companion paper to a survey of ATIS websites, Volpe National Transportation Systems Center staff compared private-sector perceptions with public-sector activities in ATIS (*2*). Naturally, traffic information figured more prominently than did transit information; however, with regard to the latter, the authors concluded:

> Transit agencies are doing a good job of providing static information, such as route schedules and fares, to the public. While some real-time information is collected on vehicle time and location, much less is being transferred to private information service providers (ISPs) or disseminated directly to the public. In part, the lack of transfer results from lack of interest on the part of ISPs. There may be a mismatch between metropolitan areas where there is a potential market for real-time transit data and metropolitan areas where data are being collected.

This section contains a brief summary of TTI systems that are part of regional information networks, community-based information networks, or both. There are several locations in the United States and abroad that have integrated TTI with other travel and nontravel information (about local communities and regions). Five primary examples are described in this section:

1. Utah's 511 System,
2. Nottinghamshire County's TravelWise,
3. Puget Sound's Smart Trek,
4. Chicago's Gateway Traveler Information System, and
5. The European Union's Transport Intermodality Data Sharing and Exchange Network.

7.1 UTA'S PARTICIPATION IN UTAH'S 511 SYSTEM

Utah DOT's (UDOT's) transportation management program, called CommuterLink, was established in April 1999. This ITS partnership includes UDOT, Salt Lake City, Salt Lake County, FHWA, UTA, Wasatch Front Regional Council, and the Utah Department of Public Safety. CommuterLink, considered the "public face" of multimodal ITS in the region, facilitates the sharing of resources and marketing efforts of participating agencies. UTA has always been part of CommuterLink, which made it easy for UTA to play a key role in the 511 system efforts.

CommuterLink helped build an excellent relationship among the participating agencies, which was critical to the success of Utah's 511 program. The development of the 511 system in Utah was expedited because of the Winter Olympics, which were held in February 2002 in Salt Lake City. The 511 Advisory Group within CommuterLink was established, consisting of officials from UDOT, UTA, Salt Lake City, Salt Lake County, the Utah Department of Public Safety/Highway Patrol, and the Utah Trucking Association. This advisory group was and continues to be essential in shaping the vision for traveler information in Utah and in coordinating the partners' actions. Planning for the 511 system began in Spring 2001, the design of the system began in Fall 2001, and the system became operational in December 2001.

UDOT was the lead agency for the 511 systems efforts, but UTA was an active participant. UTA provided transit-specific requirements to be included in the design. UTA and other advisory group members monitored and reviewed the design. In reviewing the design, UTA ensured that the system would be expandable and capable of meeting future transit needs. For example, UTA is currently upgrading the 511 system to include real-time train arrival information.

On December 18, 2001, Utah launched its 511 Traveler Advisory Telephone System. The system integrates information on road and weather conditions, incidents, congestion, transit information, and construction activities. The initial system included options for the following:

- **Traffic information:** Incident-oriented and weather-related restriction information for principal state roads and primary arterials in the Salt Lake City area and throughout the state;
- **Transit information:** UTA information on service disruptions, general messages, fares, and so forth, and the option to transfer to UTA's Customer Service Center to access a live operator;
- **Road conditions:** Weather conditions on principal state roads throughout the state (this is the same information that is currently provided via the current Utah Road Conditions Hotline); and
- **Olympics information (through the time of the Olympic Games):** Information provided by the Salt Lake Olympic Organizing Committee regarding events, transportation services, and parking and including the option of transferring to a call center to make a reservation for bus transportation to the mountain venues.

Each agency is responsible for providing its own information to the 511 system. The advisory group believed that, initially, it was not an absolute necessity to provide real-time information or all kinds of information (such as itinerary planning): therefore, transit provides static information through the 511 system. UTA is, however, planning on adding real-time train arrival information to the 511 system, as well as by phone, Internet, and WAP devices.

In an effort to expedite its planning and design efforts, the advisory group held four focus groups early in the process to help the group understand how to design the system. UTA was involved in selecting a firm to conduct the focus groups and in evaluating and monitoring focus group activities and discussions. Focus groups were engaged in evaluating different approaches to language as well as to technologies. The resulting menu structure and information provided by the system were based on input from the focus groups. Key considerations for the system suggested by the focus groups included frequent updates to the information, providing information on road conditions, and providing either a live operator or an IVR system.

The 511 system keeps track of how many callers access each mode from the menu. The number of callers accessing each mode determines the ratio of maintenance cost for each participating agency. As of February 2003, about 1,000 callers were accessing UTA information per month. This call volume has resulted in minimal maintenance cost to UTA; hence, UDOT has not asked UTA to pay for these calls. However, when the volume of calls increases, UTA anticipates covering its share of the maintenance costs.

7.2 NOTTINGHAMSHIRE COUNTY'S TRAVELWISE

In the United Kingdom, Nottinghamshire County is located approximately 130 miles north-northwest of London. There are several communities in the county, and information about them and the county is readily available on the Internet at www.nottscc.gov.uk/ (see Figure 76). In addition to detailed information about the county and individual communities, there is a link to traffic and travel information. With one click, you can enter the Nottingham TravelWise Centre (utc.nottscc.gov.uk/) (see Figure 77), which provides comprehensive traffic and transit and general travel information for the Nottinghamshire area.

TravelWise is a public awareness initiative whose purpose is to provide travelers with information prior to and during their trip so that they make the most informed decisions about the mode(s) they will use and the route(s) they will take. The service can be accessed via the Internet or telephone. TravelWise caters to automobile users, public transport users, pedestrians, cyclists, and travelers with disabilities. It is not anti-automobile, but it does promote more sensible use of automobiles by aiding travelers in making informed travel decisions and by encouraging travelers to think about the implications of individual travel decisions. TravelWise activities include local advertising (local radio, leaflets, etc.); working through local groups; making schools packs; and providing public transport travel information (*3*).

The Nottingham TravelWise system is a partnership of the City of Nottingham, the U.K.'s Highways Agency, the Nottinghamshire County Council, and BBC Radio Nottingham. The TravelWise Centre opened in October 1999 and is the U.K.'s first Mobility Centre. TravelWise started as a local authority travel awareness initiative begun by the Hertfordshire County Council in 1993. It has turned into a national campaign in the United Kingdom through the establishment of a National TravelWise Association with more than 120 local authorities participating (*4*).

Traveler information has been broadcast from Nottinghamshire's Traffic Control Centre for over a decade. In December 1997, the information service was enhanced by using the Internet as another information medium. Since 1997, the

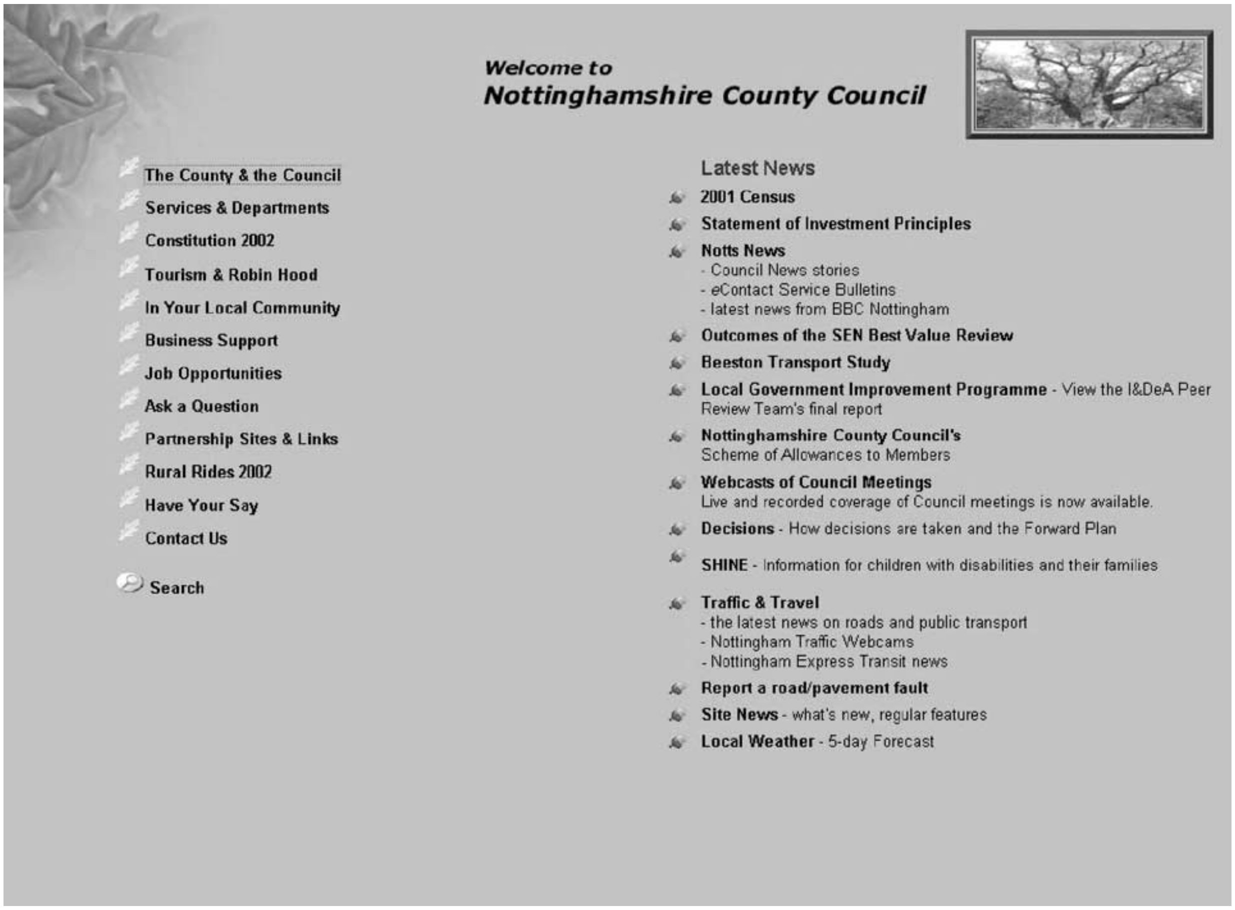


Figure 76. Nottinghamshire County website.

Figure 77. Nottingham TravelWise website.

website has been expanded to cover more information about traffic conditions, parking, public transportation information, bus and train journey planners, weather conditions, and contact numbers for various highway problems.

In Nottinghamshire County, as part of TravelWise and a new travel strategy called "The Big Wheel" (see www.thebigwheel.org.uk), real-time bus arrival information is being tested on Route 11. This real-time information is being provided at selected bus stops on the route (see Figure 78) and via the Internet (see Figures 79 and 80). Also, static timetable "next bus" information is being provided on several routes via mobile phones, as part of the Advanced Traffic and Travel Information system (ATTAIN) project. ATTAIN began in December 2001, providing information on one specific bus route, and was expanded in Spring 2002 to several more routes. Eventually, the plan is for ATTAIN to provide real-time information.

In addition to the public transport information already described above, Nottingham's TravelWise advertises the National Public Transport Information phone number, 0870-608-2-608. This hotline number is part of a U.K. initiative called Traveline (see logo in Figure 81), which provides customized local and national public transport information such as journey planning, costs, and connections for all modes. Traveline replaced Nottinghamshire County's Buses Hotline. This national service is provided by a number of regional call centers across the United Kingdom.

7.3 PUGET SOUND'S SMART TREK

Traveler information is an integral part of the community information provided via the Internet about the Washington State's Puget Sound area. The Puget Sound Regional Council (see Figure 82) provides a direct link to Smart Trek, which provides extensive traveler information, including some real-time information, for all travel modes in the greater Seattle area. As shown in Figure 83, information on traffic conditions, ferries, transit and travel planning are all on the Smart Trek website.

Smart Trek was developed originally as part of Seattle's Metropolitan Model Deployment Initiative, which was a U.S. initiative to establish model deployments of integrated ITS in metropolitan areas that demonstrated regional, multimodal traveler information services and integrated transportation management systems (*5*):

> Washington State Department of Transportation (WSDOT) entered into a partnership with public and private organizations to implement ITS solutions [in the Puget Sound area]. This partnership was named "Smart Trek". . . . The Smart Trek program built upon existing ITS institutional relationships and infrastructure in the Seattle region to showcase an integrated Intelligent Transportation Infrastructure (ITI). Smart Trek integrated new and existing data sources; established a transportation information network that is integrated, regional, and multimodal; and greatly expanded the distribution of traveler information.

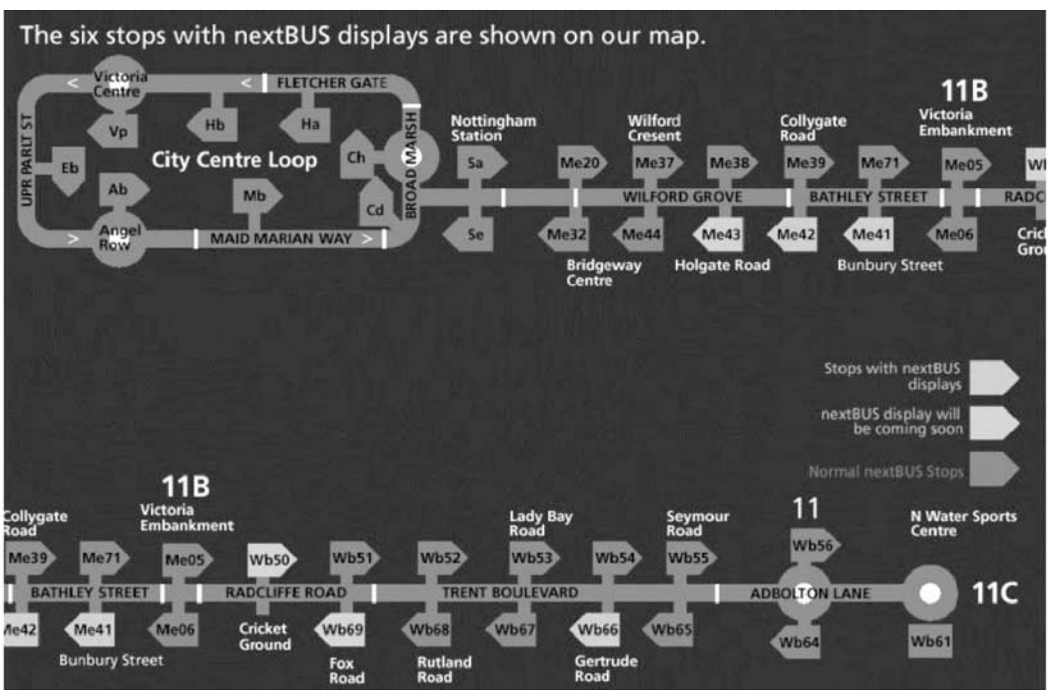


Figure 78. Stops on Route 11 that have and will have next bus displays.

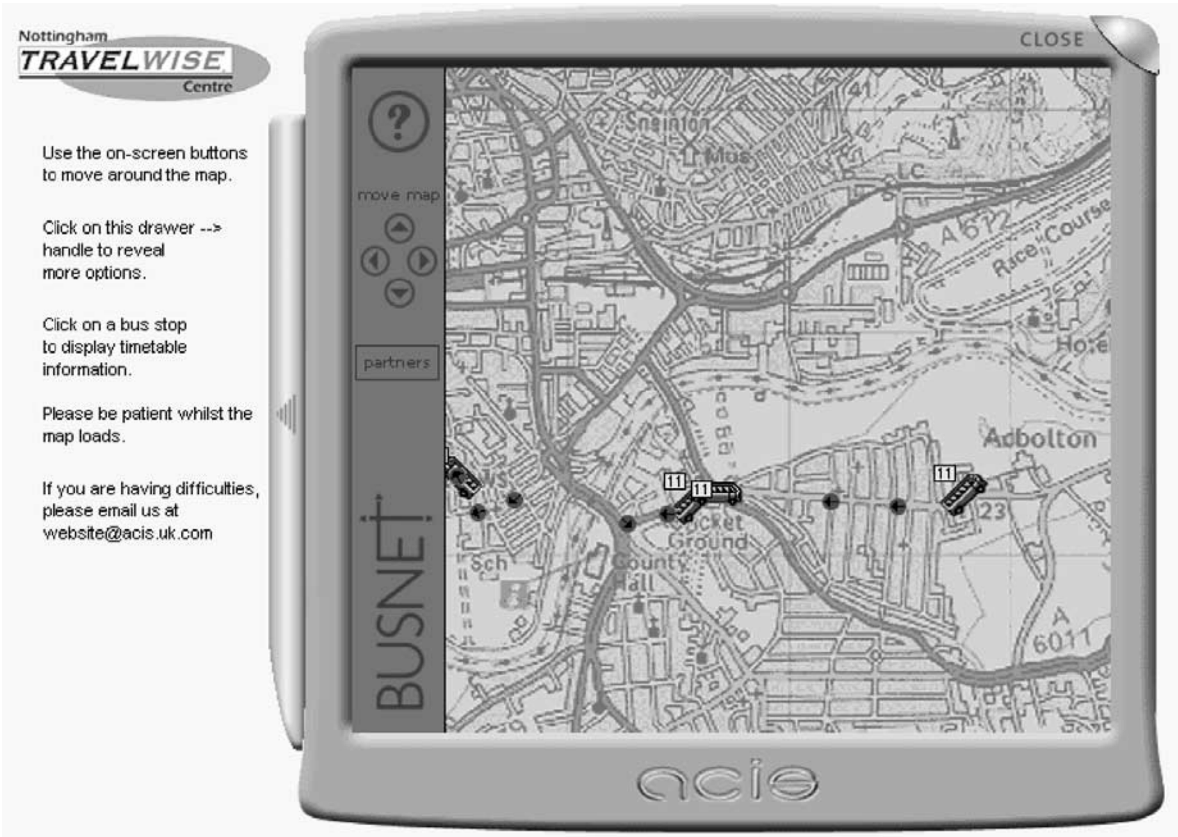


Figure 79. Real-time bus information on Route 11 via the Internet.

7.4 CHICAGO'S GATEWAY TRAVELER INFORMATION SYSTEM

The Gary–Chicago–Milwaukee corridor, with many ITS systems already in place, is the subject of a significant plan for ITS deployment. This corridor, which was established as an ITS Priority Corridor in 1991, "links the transportation infrastructures in Illinois, Indiana and Wisconsin, including all major freeways, airports, transit, commuter, and freight railroad systems" (*6*). In 1995, a regional Multi-Modal Traveler Information System (MMTIS) was defined in a Corridor Program Plan. The MMTIS, also known as the "Gateway," includes participation from all Chicago transit agencies (also know as the service boards: Chicago Transit Authority [CTA], Metra, and Pace) under the umbrella of the Chicago Regional Transportation Authority (RTA), in addition to all corridor traffic management agencies.

The Gateway Traveler Information System (TIS) is a distributed system that collects static and dynamic data through regional hubs and distributes "corridor-wide data to operating agencies, information service providers, such as the media, and to planners and researchers. Regional hubs also have the

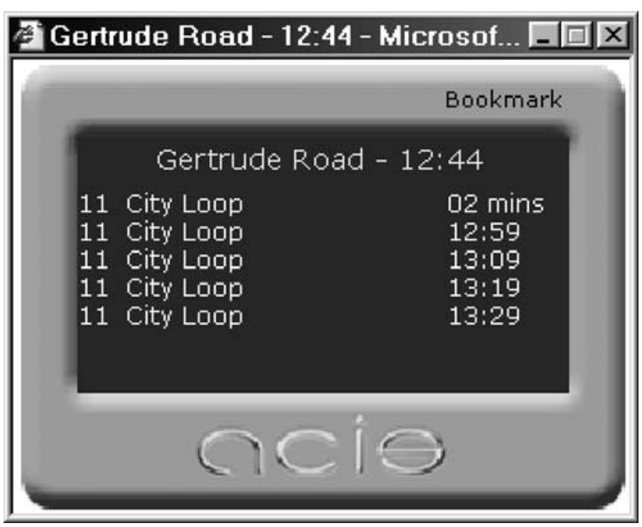


Figure 80. Real-time bus information for the Gertrude Road stop on Route 11.

traveline
public transport info
0870 608 2 608

Figure 81. National Traveline logo.

Figure 82. Puget Sound Regional Council homepage.

ability to distribute data they collect but will not be distributing corridor-wide data" (*7*). Transit is a prominent player in the Gateway TIS, and the entry point to the Gateway TIS for Chicago-area transit agencies is the Illinois Transit Hub (ITH). A functional architecture for the ITH was developed by the Chicago RTA, which includes several key elements, as follows (*8*):

- Data provided to the ITH by Chicago-area transit operators will include route and schedule information, fare information, current on-time status and location, annulments and cancellations, late pullouts, delays with cause and expected duration, parking occupancy information, and incident reports. Service boards may also provide certain requests or advisories to traffic management centers through the ITH, including center-to-center signal priority requests and information concerning highway-rail intersection status.
- Data forwarded by the ITH to the Gateway includes selected transit schedule, route, fare and current on-time status information, as well as transit incidents. The ITH will forward updated information every minute to ensure that the information provided to travelers is as current as possible.
- The ITH tracking database will support various traveler information applications by maintaining current location and on-time status for any vehicles reported to the ITH.
- An ITH website will provide a full range of information access to transit travelers and, in the future, will support management of traveler profiles for personalized TTI.
- The ITH will obtain and provide traffic information relevant to transit operations from the Gateway system. This information may include traffic incidents affecting transit routes, travel times, road closures or lane reductions, and information on highway-rail interchange status.
- The ITH will host specialized applications such as the Transfer Connection Protection System, which will examine transit status reports to identify endangered connections, and Active Transit Station Signs at joint stops or at stations that display status information for more than one service.

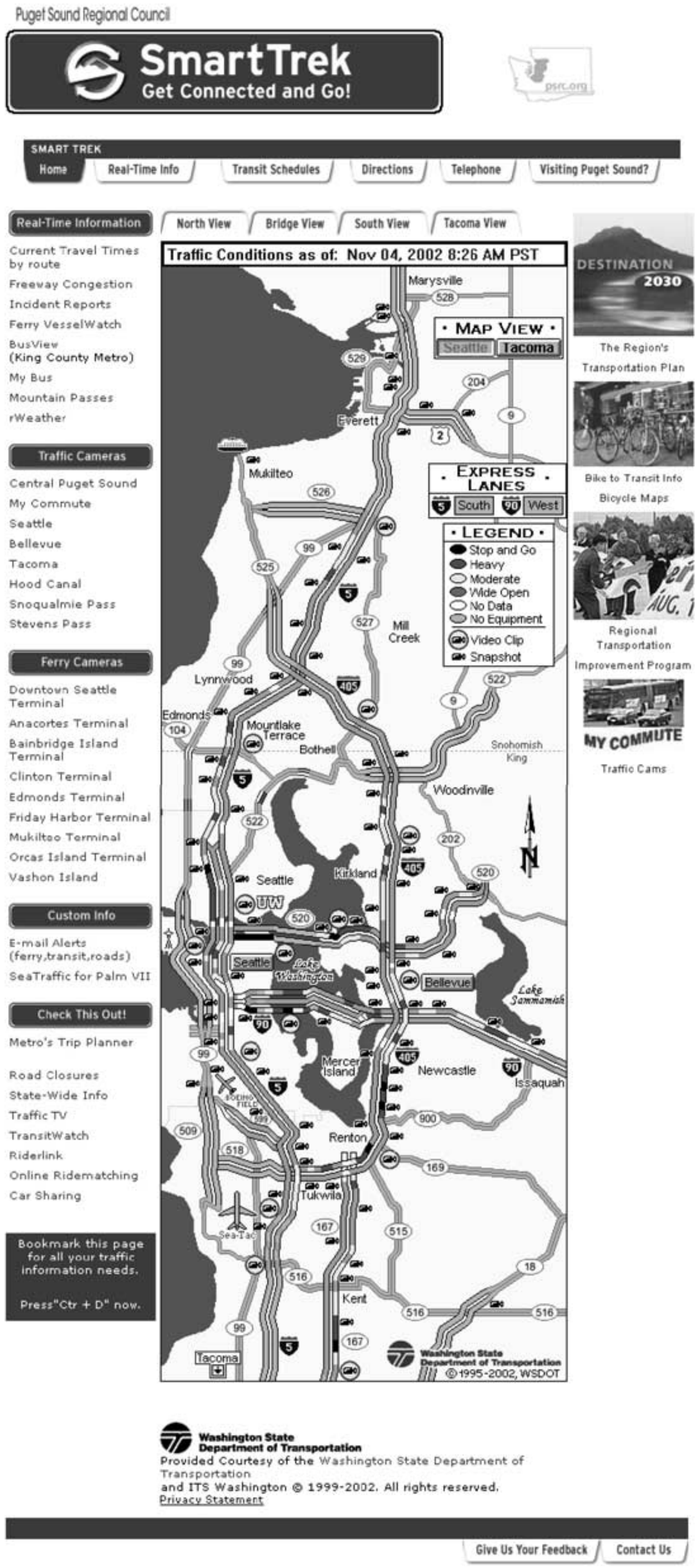


Figure 83. Puget Sound traffic information.

Chicago RTA's development and deployment of the ITH depends on the transit ITS infrastructure, which is focused in four distinct technology areas: (1) traffic signal control, (2) traveler information, (3) transit management, and (4) electronic payment. Many projects are currently being conducted in these areas to provide the necessary infrastructure. While Chicago RTA realizes that there are significant challenges for transit to coordinate on a regional scale to fully participate in the Gateway, it has identified three opportunities for coordination that emphasize the benefits of its approach (*9*):

1. Service improvements through better dispatching information and tools that provide decision support for interagency transfers and transit signal priority operations;
2. Traveler information availability that includes not only schedules and fares, but also up-to-date on-time status for buses and trains; and
3. Sharing of information between transit and traffic managers, improving both highway and transit performance and safety and security of trips.

Chicago RTA's approach to participating in the Gateway TIS can be used as an example of how transit can play a significant role in regional information systems. Its structured development of a regional transit ITS plan ensures that comprehensive TTI is provided to the public in the future.

7.5 EUROPE'S TRANSPORT INTERMODALITY DATA SHARING AND EXCHANGE NETWORK

Europe's TRansport Intermodality Data sharing and Exchange NeTwork (TRIDENT) project addresses the issue of standards for travel data. While this project is not specifically related to providing regional or community-based traveler information, it represents an important step in integrating disparate travel data and traveler information systems in a region. The goal of TRIDENT, which was funded in part by the European Union Information Society Technologies Framework, was to support multimodal traveler services by establishing common and reusable mechanisms that enable sharing and exchanging data among transport operators

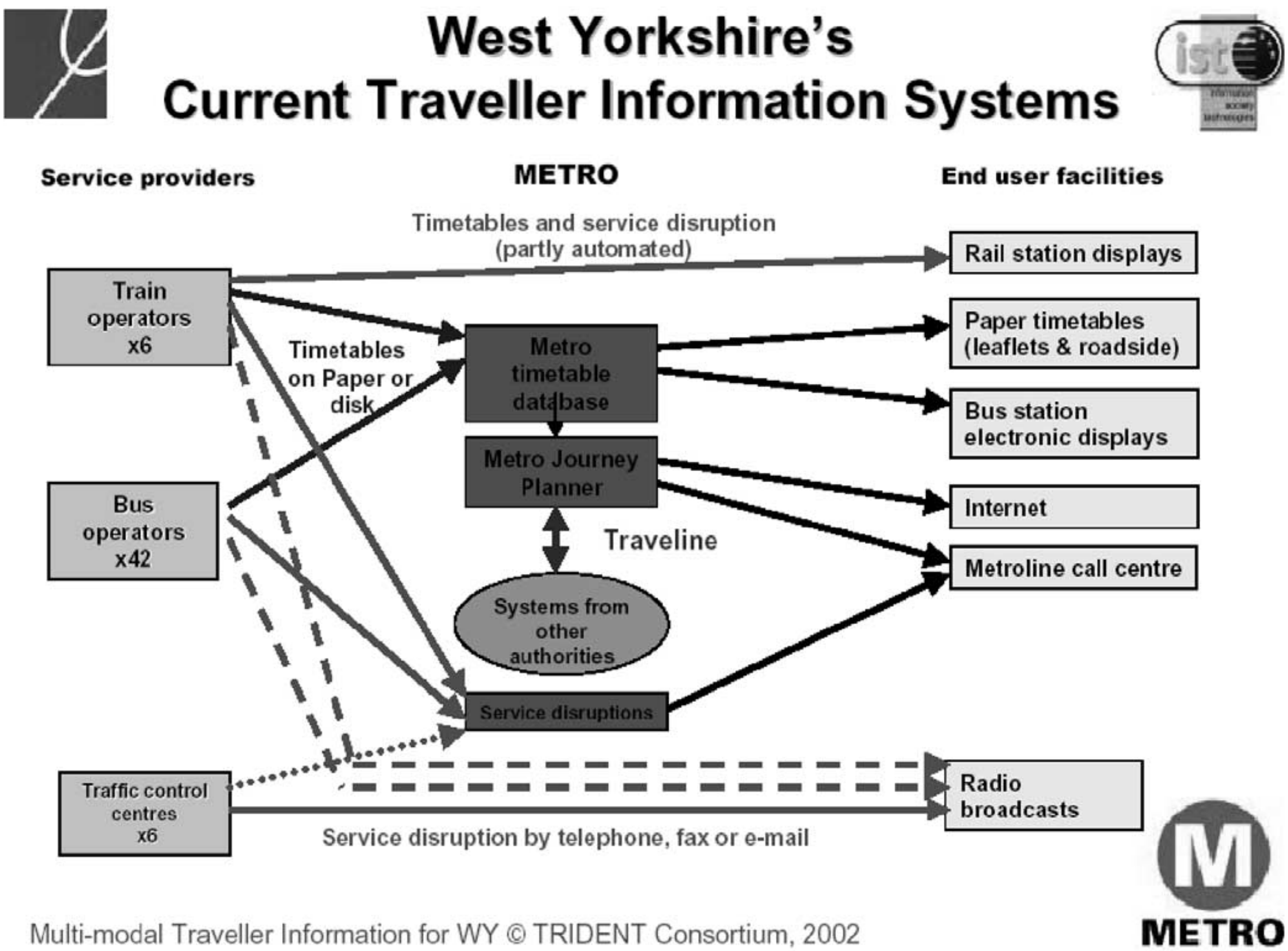


Figure 84. West Yorkshire's current traveler information systems (13).

(i.e., content owners) of different modes (e.g., bus, light rail, subway, commuter rail, and highway) as well as ISPs. TRIDENT investigated and proposed solutions for the organizational and strategic issues that often hinder travel intermodality. This 30-month project ended in 2002 and tested specifications at four sites: Flanders, Belgium; Paris, France; Rome, Italy; and West Yorkshire, United Kingdom (*10*).

The West Yorkshire test best illustrates the benefits of TRIDENT and shows how an integrated traveler information system using TRIDENT specifications could become a key component of regional or community information systems: (*11*)

> Metro is the public body responsible for coordinating public transport in West Yorkshire. It has a key role in providing passenger information in a range of formats, including via a call centre. The information is obtained from a variety of sources including private bus and rail operators.

In West Yorkshire, there are 6 train operators, 42 bus operators, and 6 traffic control centers. Prior to TRIDENT, traveler information was collected and disseminated as shown in Figure 84 (*12*):

> In West Yorkshire the TRIDENT specifications will be used to support the introduction of real time multi-modal public transport information using object oriented technologies. In particular it will be used to provide integrated real time information for bus-rail links in the Denby Dale area linking real time bus information with similar information for trains. Information on delays and cancellations from train operators will be shared with Metro and combined with real time bus information held by Metro's own systems. This will form the basis of a real time enquiry system capable of providing information for multi-modal journeys involving both bus and train.
>
> Real time information for both buses and trains will be displayed on a single screen at locations such as Denby Dale and made available to the public initially via Metro's telephone enquiry line. The availability of multi-modal real time information will allow the passenger to make a more informed travel choice especially on occasions where there are disruptions to the service. It is anticipated that the system will be extended to cover West Yorkshire in the future with other retail channels being introduced.

After the full implementation of TRIDENT, traveler information in West Yorkshire will be collected, processed, and disseminated as shown in Figure 85.

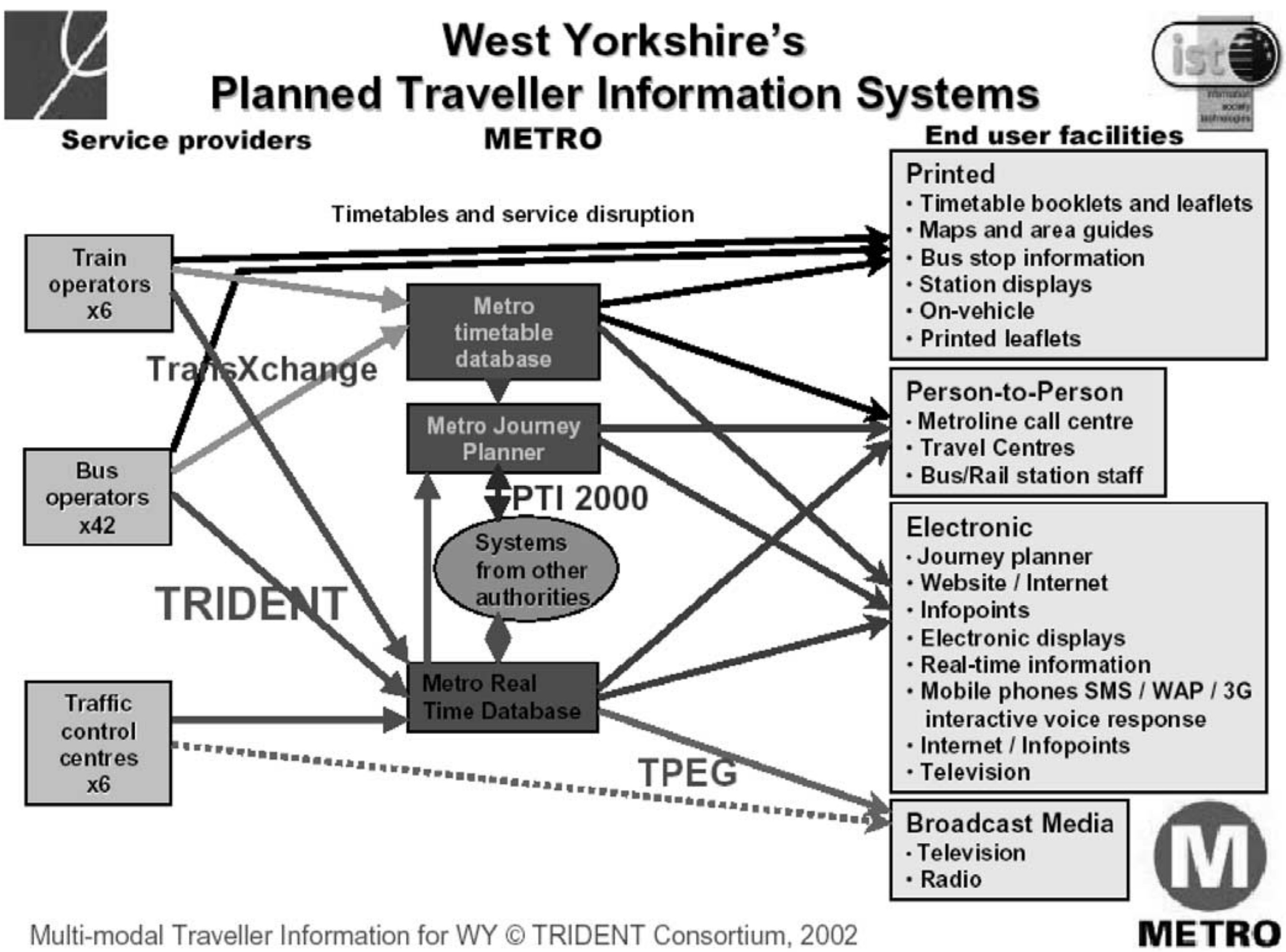


Figure 85. West Yorkshire planned traveler information systems (14).

7.6 REFERENCES AND ENDNOTES FOR SECTION 7

1. On July 21, 2000, the Federal Communications Commission assigned 511 as the nationwide telephone number for traveler information. 511 is being deployed around the country by state and local agencies to provide statewide and regional traveler information. While the primary focus of 511 deployment has been on providing traffic conditions, transit information has been provided by many of the current and planned 511 deployments. The majority of the U.S. population will have access to a 511 system by 2005.
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4. www.dft.gov.uk/itwp/paper/chapter5/10.htm.
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10. www.ertico.com/activiti/projects/trident/goal.htm.
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14. Ibid.

SECTION **8**

FUTURE DIRECTIONS

From the research conducted during this project, it is clear that the transit industry is making significant inroads in improving TTI. While complete integration with other traveler information is still in its infancy, TTI has been proven to improve the perception of transit services and to have the potential to result in a mode-shift toward public transit. However, continued improvements must be made in TTI to ensure this mode-shift.

During the course of this research effort, four key strategies for improved TTI have been identified; the strategies are being deployed by transportation agencies outside the United States or have been implemented by nontransit industries. These strategies are as follows:

1. Improving the data that provides the basis for TTI;
2. Completely integrating TTI with other traveler information, particularly traffic information for "one-stop" regional information shopping;
3. Providing more customer-focused and personalized information, such as bus stop–level schedules and maps and IVR systems; and
4. Providing real-time information using a variety of dissemination media.

In each subsection below, the best examples of agencies that have met these challenges in providing improved TTI are presented.

8.1 IMPROVEMENT OF UNDERLYING DATA

While the importance of developing and maintaining accurate and comprehensive data that provides the basis for TTI applications has been discussed earlier in this report, it is a key strategy that can be used to improve traveler information. Data quality directly affects everything along the "information chain," as described as follows (*1*):

> The information chain from collection of raw data through its conversion into meaningful information to its delivery to end users will usually involve a number of organizations spanning the public and private sector. A common division of responsibilities seen in partnerships is as follows. The public authority has the role of data provision and maintenance of data quality. Meanwhile the private organizations have the role of using that data to deliver (commercial) information services to the public.

Thus, if the initial data used by a public agency to generate information for dissemination is not accurate, the information will not be accurate. This lack of accuracy of the underlying data can have significant consequences for the public's perception of the information; therefore, the public's use of the information may be reduced. There are four areas in which data quality can be improved to, in turn, improve TTI:

1. Level of detail,
2. Coverage,
3. Accuracy, and
4. Maintenance.

8.1.1 Level of Detail

The level of data detail affects TTI in several ways. For example, data detail can affect routing from Point A to Point B, depending on the customer's mode of travel: "The most suitable route for a pedestrian, for example, might not be the same as that for a cyclist both in terms of the attractiveness of that route and its distance" (*2*). Further, the information generated by scheduling and itinerary-planning systems that rely on bus-stop inventories can be affected by the level of detail provided in the inventory. For example, if a scheduling and itinerary-planning system is being used to guide a person with disabilities from his or her home to a bus stop, it is very important to know whether the path of travel is accessible. Such level of detail may not be necessary for other TTI applications, but it is critical in this type of application.

8.1.2 Data Coverage

Data coverage can be critical, particularly when a customer is traveling within a region that has multiple modes or a wide geographic area. For example, if a customer is traveling from San Francisco to San Rafael in Marin County, California, the data underlying the itinerary-planning engine must contain not only data for transit services within the city that will take the customer to the Golden Gate Transit Larkspur Ferry, but also data for services that connect to the ferry once the ferry is at Larkspur Landing (in this case, Golden Gate Transit bus services).

8.1.3 Data Accuracy

Data accuracy also significantly affects the accuracy of TTI. For example, if the specific geographic location of a bus stop is in error, several TTI elements will be in error, including real-time arrival or departure information for that stop; onboard next-stop announcements, which could be made at the wrong time; and itineraries that involve that stop. If the location of a bus is not accurate, it will affect the accuracy of the prediction of when that bus is going to arrive at the upstream stops.

8.1.4 Data Maintenance

Data maintenance must be performed on a regular basis to ensure continuing data accuracy. Further, as is implied in Section 4, data maintenance can be optimized if an agency maintains only one database that is used for all TTI applications. Often, this is a challenge because different TTI applications need varying levels of detail and coverage. Historically, agencies have had multiple bus stop inventories: one to drive a scheduling system; one to drive an AVL system; one to drive the onboard annunciation system; and so forth. With just one comprehensive bus stop inventory, data maintenance is facilitated, as is building interfaces from each TTI application to this data. For example, it would be ideal to have one bus-stop inventory that underlies scheduling, AVL, onboard annunciation, automatic passenger counting, real-time transit information, trip and itinerary planning, and IVR systems.

8.2 INTEGRATION WITH OTHER TRAVELER INFORMATION

A Thematic Long-term Approach to Networking for the Telematics and ITS Community (ATLANTIC) is a project funded by the European Commission, U.S DOT ITS Joint Program Office, and Transport Canada. ATLANTIC is reviewing “the coverage, content and results of European, American and Canadian ITS research and development programs” (*3*). ATLANTIC supports eight forums, two of which specifically address ATIS (i.e., the Telematics-based Traffic and Travel Information Services and Intermodal Collective Transport Information forums). This 18-month project, which ends in December 2002, has done a significant amount of work in examining the present and future of ATIS.

As part of ATLANTIC, a review of U.S. ATIS business models was shared with ATLANTIC participants, and comments were made on this review from a European perspective (*4, 5*). While traffic information was the primary focus of the model review and subsequent European comments, there are many issues that directly relate to the future of TTI systems, as follows:

- **Integration with traffic information:** There are formidable social barriers to providing public transport information; these barriers make it difficult for politicians to challenge the automobile culture by investing in ATIS that provide both transit and traffic information (*6*). However, users have expressed a need for multimodal traveler information: “In Europe, the largely coordinated approach to traffic and travel data appears to have resulted in the establishment of a robust value chain and the identification by key players of profitable positioning points within that value chain” (*7*).
- **Sale of public data, systems, or both:** In terms of TTI, public transit has the opportunity to sell its data (e.g., real-time bus arrival information), “as long as the data being sold is of sufficient quality and is on a level that the private sector cannot replicate by gathering similar data on their own” (*8*). Given that the private sector cannot replicate public transit operational data, this could give transit a distinct advantage in selling its data. Transit agencies selling their data could turn around the relatively recent market of firms that provide transit agencies with a for-fee service that collects, processes, and disseminates real-time information.
- **Content of TTI:** The need for travel time data has been expressed. This is an area that public transit has not undertaken to date. If travel times were provided as part of TTI (and could be compared with the travel times on other modes), the public would be able to make more informed choices about mode(s), route(s), and so forth.

The many presentations made in association with the ATLANTIC project have the same theme—the integration of information services provides the most value to the user of ATIS, of TTI services, or of both. Many current (as of December 2002) projects in the United Kingdom and Europe are focused on the full integration of traveler information, such as Transport Direct, which was mentioned earlier in Section 3.2. In a presentation given at the 8th World Congress on ITS, Transport Direct—a fully integrated system—was presented, as shown in Figure 86 (*9*). Note that Traveline is an existing U.K. system to provide TTI throughout the United Kingdom by dialing one phone number (0870-608-2-608).

Further, over and over again, the idea of providing travel times using various modes has been expressed, representing the need for complete integration of transit and other traveler information. Calculating travel times for different modes is not trivial and would require that many sources of data be combined and processed to predict travel times and that a rather sophisticated algorithm be developed to perform this calculation. In order to handle data from multiple sources, the data would have to be stored using a standard. The TRIDENT

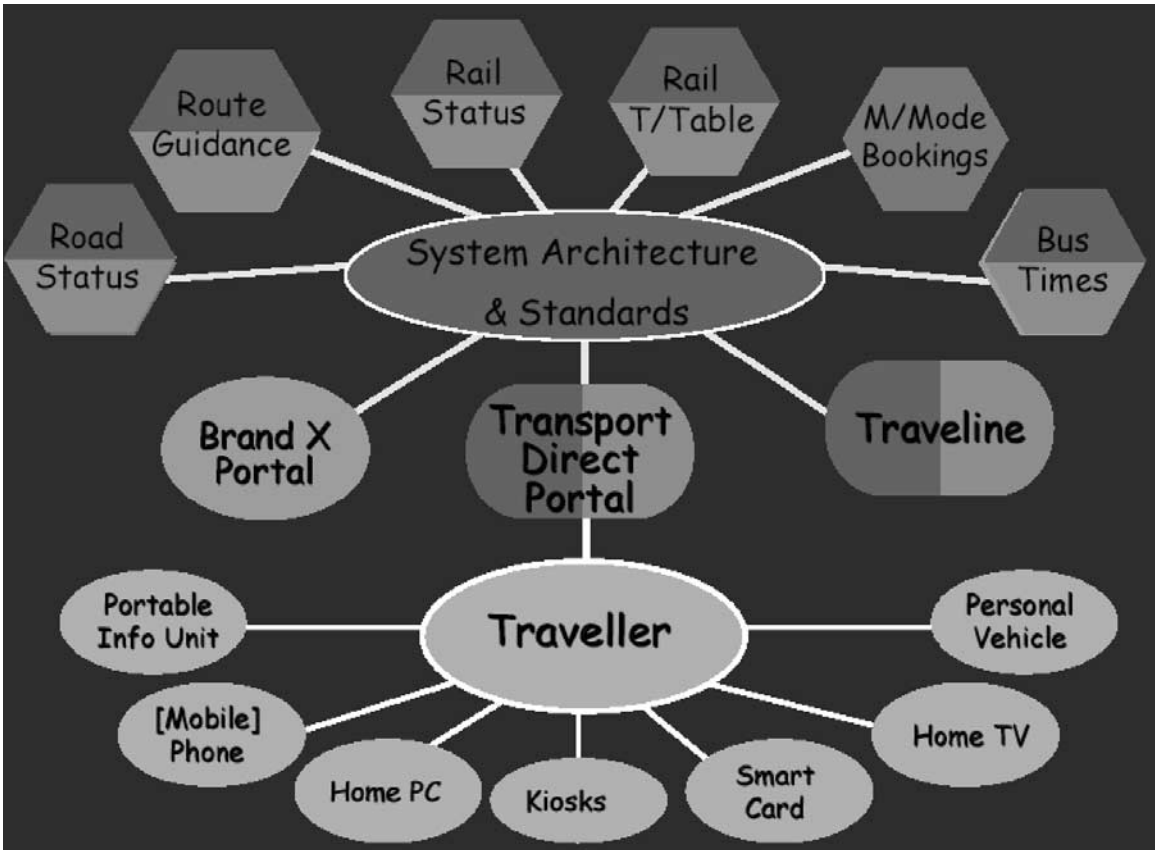


Figure 86. Vision for Transport Direct in 2003 and beyond.

project, which was described in Section 7.5, addresses the issue of standards for travel data. However, if the ultimate goal of improved TTI is to be completely integrated with other travel and on-travel services, standards alone are not going to generate such improvements.

Developing an algorithm that is sophisticated enough to produce accurate and reliable travel time predictions has recently been achieved through the DOM project, which was described in Section 5.2.5. In DOM, multimodal routing includes a comparison between travel times and costs for travel by public transport and travel by car (*10*):

> The traveling times for cars consider the individual streets' speed profiles and figures drawn from past experience. The costs are calculated on the basis of values from the German automobile association. The intermodal public transport route is calculated using all forms of public transport (rail and local forms of transport) as well as footpaths and taxi trips.

The evaluation of DOM is not yet complete, so the user's perception of the reliability and accuracy of the travel time predictions is not yet known. In any case, North American transportation agencies should take note of the results of this and other similar initiatives in the United Kingdom and in Europe in order to begin achieving full integration of TTI and other travel information.

Three U.S. initiatives that are attempting to achieve full integration include the 511 system (as mentioned in Section 7.1), the Intermodal Passenger Information System, and TRIPS123. As of February 2003, fourteen 511 systems have been deployed, with many more deployments expected in the near future. While transit has not always been a component of deployed 511 systems, there has been an emphasis on including transit. Further, there have been many discussions of including real-time transit information via 511, if it is available. For example, Utah's 511 system will eventually contain real-time train arrival information for UTA.

An example of a 511 system that may eventually include real-time transit information in addition to real-time traffic and related National Park information is the Tri-State Advanced Rural Traveler Information System (TRIO), which is under development for the states of Maine, New Hampshire, and Vermont. Several technologies (collectively called the TRACKER system), including a real-time transit information system, have been deployed in the bus system in Bar Harbor, Maine, called the Island Explorer. This system, which operates from mid-June through Labor Day each year, serves Acadia National Park and the surrounding communities. It has been proposed that TRIO, which will be integrated into the 511 system, include the real-time departure information that is generated by the TRACKER system.

The Intermodal Passenger Information System is best described as follows (*11*):

> [The] project is a multi-phase effort to implement a fully integrated intermodal and multimodal traveler information system for trips anywhere in the Northeast Corridor. Such an integrated system would provide travel information for long distance, inter-city travelers from origin to destination at various stages of the trip process: trip planning, trip initiation, and en-route. Stage 1 efforts have assisted in linking the trip planning systems of Greyhound and New Jersey Transit; soon to be added are the trip itinerary planning systems of SEPTA, WMATA and MdMTA [Maryland Transit Administration in the Baltimore area]. This effort is also being coordinated with the work FTA is advancing in trip planning at the federal level.

TRIPS123, which is expected to be operational in early 2003, is a multimodal traveler information system for the New York–New Jersey–Connecticut region. The system comprises three distinct services: (1) the free Traveler Information Center, which allows travelers to make better informed travel choices; the free Transit Advisory System, which assists travelers to make regional trips using multiple carriers; and the for-fee Personalized Traveler Service, which proactively alerts travelers about any events that could affect their travel times (*12*).

In terms of the need for standards that specifically address the integration of TTI with other traveler information, the development of the National Transportation Communications for ITS Protocol (NTCIP) is supposed to fulfill that need (*13*):

> NTCIP is a family of communications standards for transmitting primarily data and messages between microcomputer control devices used in Intelligent Transportation Systems (ITS). NTCIP is intended for use in all types of management systems dealing with the transportation environment, including those for freeways, traffic signals, transit, emergency management, traveler information, and data archiving. NTCIP is intended for use between computers in different systems or different management centers, and between a computer and devices at the roadside. NTCIP allows agencies to exchange information and (with authorization) basic commands that enable any agency to monitor conditions in other agencies' systems, and to implement coordinated responses to incidents and other changes in field conditions when needed.

The use of NTCIP is not widespread enough yet to have solved the basic problem of multiple transportation agencies providing data into one repository, which then disseminates the information to the customer. The TRIDENT project in Europe, described in Section 7.5, has begun to be successful in addressing this issue.

The Transit Communications Interface Profile (TCIP) is the transit series of standards that are part of the NTCIP family. TCIP contains nine data and message standards, as follows:

1. **NTCIP 1400: TCIP Framework**
2. **NTCIP 1401: Common Public Transport Objects**
3. NTCIP 1402: Incident Management
4. **NTCIP 1403: Passenger Information**
5. **NTCIP 1404: Scheduling and Runcutting**
6. **NTCIP 1405: Spatial Representation**
7. NTCIP 1406: On-Board
8. NTCIP 1407: Control Center
9. NTCIP 1408: Fare Collection

Of the nine standards, five are directly related and used in TTI systems. These are numbers 1, 2, 4, 5, and 6 in the list above. Currently, FTA and APTA are leading an effort to complete the standards development and to expedite deployment of systems using the standards. A pilot implementation of a TTI system using the standards is being planned for Summer 2003.

As mentioned in Section 5.2.4, there are several aspects of this project that are unique to most TTI systems and have applicability to providing TTI services in the United States. First, this personalized service must process and integrate data from several different sources. The architecture, which was shown in Table 10, identifies categories of the providers of information and transit services as follows:

- Content owner;
- Content provider;
- Service operator;
- Service provider; and
- Network provider.

This categorization could be used in the United States; however, as of December 2002, most U.S. transit agencies that provide TTI services are owners and providers of content and service. Perhaps using a more distributed architecture, such as the one used in PIEPSER, would relieve transit agencies of the responsibilities associated with directly providing such information. On the other hand, having transit agencies directly provide this information ensures the quality of the information.

Second, this service is provided to a limited number of transit customers—those who purchase monthly transit passes. These pass buyers have the option to subscribe to this service. If they subscribe, data on their regular transit trips is recorded, along with their mobile telephone number. Limiting the service to pass holders minimizes the data processing required.

Third, Unified Modeling Language (UML) is the standard language used for system design and software. Using a standard language such as UML facilitates the system design by allowing both actual and conceptual components to be defined (*14*):

> [PIEPSER] does not only deliver disruption messages [via Short Message Service], but also suggestions on alternative ways to act. The generation of these scenarios takes into account the traffic conditions regarding traffic flow and the availability of car parks. Furthermore, information is also provided on current road works and diversions.

8.3 PROVISION OF MORE CUSTOMER-FOCUSED AND PERSONALIZED INFORMATION

Throughout this report, the idea of what the customer needs has been discussed frequently. Several TTI systems that provide personalized TTI have been presented to show how transit agencies are becoming more customer-focused, and the fact was discussed that choice riders are no longer satisfied with paper schedules and speaking to a customer service operator to obtain TTI. In this section, two examples of improved TTI that integrate other traveler information, an element discussed in Section 8.2, are presented: stop-specific timetables and IVR technology.

8.3.1 Stop-Specific Timetables

Transport for London recognized the need to provide improved static and dynamic traveler information to the public. The Countdown system, previously described in detail in Section 5.2.1, is providing real-time information to the public at bus stops. In terms of static data improvements, Transport for London has redesigned bus timetables and maps to provide customers with information at the bus stop level. Through Transport for London's website, customers can obtain bus stop specific schedules (journeyplanner.tfl.gov.uk/user/XSLT_STT_REQUEST?language=en, as of December 2002).

London Bus timetables that were available before stop-specific timetables were developed, such as the one shown in Figure 87, were typical schedules showing all stops along the route and the time that the bus would be at each stop (*15*). These timetables were viewed as difficult to understand, did not provide clear information about the bus at an individual stop, and did not reflect how the buses actually run.

Stop-specific timetables, such as the one shown in Figure 88, were designed based on extensive customer research. Customer response has been very positive since the distribution of these schedules, which started in March 2002. It is expected that all 65,000 timetables will be available by the end of the 15-month rollout (the rollout is being done by area) in June 2003. The features of these stop-specific timetables are as follows:

- From a bus user's point of view, the timetable
  - Provides information about his or her bus from his or her stop,
  - Is easy to read and understand, and
  - Reflects how the buses actually run.
- The design features include the following:
  - The frequency chart portion of the timetable, which
    - Removes "spurious accuracy,"
    - Provides information in a large font size,
    - Has clear time banding,
    - Uses a 12- and 24-hour clock,
    - Shows first and last buses, and
    - Shows night buses separately.
  - The route diagram portion of the timetable, which
    - Shows the direction of travel,
    - Shows the current stop,
    - Shows where the bus has been,
    - Shows the approximate journey time, and
    - Clearly links the Night Bus route with frequency.

Spider maps, similar to the familiar London Underground maps, were developed recently to show bus services from specific stops (see Figure 89). Multiple maps are provided for each borough in London (www.tfl.gov.uk/buses/route_maps.shtml). These maps, which were developed based on considerable customer research, are much easier to use than the standard bus maps and give an easy-to-understand graphical view of all of the bus services emanating from a specific stop. Most of the high volume bus stops have spider maps available.

Transport for London also has an interactive map that a customer can use to generate information about particular London Underground stations, including information on bus connections, bus spider map (if available), train times, station facilities, station access, a local area map, and the opening hours if there is a travel information center at that particular stop.

Another improvement in customer-focused information is the use of IVR systems. Voice recognition technology provides the basis for IVR systems, which are beginning to be used to provide TTI. IVR systems can include the following functionality:

- Automatic speech recognition and text to speech (as used by Denver RTD and described in Section 4.2.1);
- Provision of general transit information, including hours of operations, fares, and so forth;
- Paratransit trip reservations, confirmation, and cancellation;
- Paratransit trip notification, which notifies the customer a certain amount of time before the vehicle is scheduled to arrive;
- Transit pass sales;
- Provision of real-time transit information, such as ETA for a specific bus stop;
- Administration of customer surveys; and
- Provision of trip- or itinerary-planning information.

8.3.2 IVR Technology

WMATA's RideGuide system, which was described in Section 4.2.1, is available via telephone using IVR technology. This system, implemented in November 2002, allows callers

8 Daily / N8 Every night

Victoria - Oxford Circus - Bow
Victoria - Stratford - Woodford Wells/Newbury Pk

Mondays to Fridays

Victoria Station ⊖ ⇌	0550	0605	0620	0633	0645	0657	0707	0717	0727	0735		2103		2325	2340
Hyde Park Corner ⊖	0553	0608	0623	0636	0648	0700	0710	0720	0730	0739		2106		2328	2343
Oxford Circus ⊖	0559	0614	0629	0642	0654	0707	0717	0727	0739	0749	Then	2113	Then	2335	2350
Holborn Station ⊖	0607	0622	0637	0650	0703	0716	0726	0736	0748	0758	about	2123	about	2343	2358
Bank Station ⊖ *DLR*	0617	0632	0647	0700	0713	0726	0736	0748	0800	0810	every	2131	every	2350	0005
Liverpool Street Station ⊖ ⇌	0620	0635	0650	0703	0717	0730	0742	0754	0806	0816	6-8	2134	10	2353	0008
Shoreditch *Great Eastern Street*	0623	0638	0653	0706	0720	0733	0745	0757	0809	0819	minutes	2137	minutes	2356	0011
Bethnal Green Station ⊖	0628	0643	0658	0712	0726	0740	0752	0804	0816	0826	until	2142	until	0001	0016
Old Ford *Parnell Road*	0634	0649	0705	0720	0735	0749	0801	0813	0825	0835		2149		0007	0022
Bow *Church DLR*	0638	0654	0710	0725	0740	0755	0807	0819	0831	0841		2153		0011	0026

Saturdays

Victoria Station ⊖ ⇌	0550	0610	0630	0650	0710	0728	0742	0755	0807		0914	0921		1930		2325	2340
Hyde Park Corner ⊖	0553	0613	0633	0653	0713	0731	0745	0758	0810		0919	0926		1934		2328	2343
Oxford Circus ⊖	0559	0623	0643	0703	0723	0739	0753	0806	0818	Then	0928	0935	Then	1943	Then	2335	2350
Holborn Station ⊖	0607	0627	0647	0707	0727	0747	0801	0814	0826	about	0936	0943	about	1953	about	2343	2358
Bank Station ⊖ *DLR*	0617	0637	0657	0717	0737	0757	0811	0824	0836	every	0946	0953	every	2003	every	2350	0005
Liverpool Street Station ⊖ ⇌	0620	0640	0700	0720	0740	0800	0814	0827	0839	8-10	0949	0956	7	2006	10	2353	0008
Shoreditch *Great Eastern Street*	0623	0643	0703	0723	0743	0803	0817	0830	0842	mins	0952	0959	mins	2009	mins	2356	0011
Bethnal Green Station ⊖	0628	0648	0708	0728	0748	0808	0822	0835	0847	until	0957	1004	until	2014	until	0001	0016
Old Ford *Parnell Road*	0634	0654	0714	0734	0754	0814	0828	0841	0853		1006	1015		2021		0007	0022
Bow *Church DLR*	0638	0658	0718	0738	0758	0818	0832	0846	0858		1011	1020		2026		0011	0026

Sundays and Public Holidays

Victoria Station ⊖ ⇌	0550	0620	0650	0720	0735	0750	0805	0820	0835	0850	0903	0916		1040		2325	2340
Hyde Park Corner ⊖	0553	0623	0653	0723	0738	0753	0808	0823	0838	0853	0906	0919		1044		2328	2343
Oxford Circus ⊖	0559	0629	0659	0729	0744	0759	0814	0829	0844	0859	0912	0925	Then	1052	Then	2335	2350
Holborn Station ⊖	0607	0637	0707	0737	0751	0806	0821	0836	0851	0906	0919	0932	about	1102	about	2343	2358
Bank Station ⊖ *DLR*	0617	0647	0717	0747	0759	0814	0829	0844	0859	0914	0927	0940	every	1110	every	2350	0005
Liverpool Street Station ⊖ ⇌	0620	0650	0720	0750	0802	0817	0832	0847	0902	0917	0930	0943	12	1113	10	2353	0008
Shoreditch *Great Eastern Street*	0623	0653	0723	0753	0805	0820	0835	0850	0905	0920	0933	0946	mins	1116	minutes	2356	0011
Bethnal Green Station ⊖	0628	0658	0728	0758	0810	0825	0840	0855	0910	0925	0939	0953	until	1124	until	0001	0016
Old Ford *Parnell Road*	0634	0704	0734	0804	0816	0831	0846	0901	0916	0931	0947	1001		1133		0007	0022
Bow *Church DLR*	0638	0708	0738	0808	0820	0835	0850	0905	0920	0936	0952	1006		1138		0011	0026

Route N8 - Sunday night/Monday morning to Thursday night/Friday morning — Fri night/Sat morn & Sat night/Sun morn

Victoria Station ⊖ ⇌	2355	0015	0035	0055	0115	0135	0155		25	55		0425	0455	0525	2355	---	0015	0025
Hyde Park Corner ⊖	2358	0018	0038	0058	0118	0138	0158		28	58		0428	0458	0528	2358	---	0018	0028
Oxford Circus ⊖	0006	0026	0046	0106	0126	0146	0206		36	06		0436	0506	0536	0006	A	0026	0036
Holborn Station ⊖	0018	0038	0058	0118	0138	0158	0218		48	18		0448	0518	0548	0018	0028	0038	0048
Bank Station ⊖ *DLR*	0025	0045	0105	0125	0145	0205	0225		55	25		0455	0525	0555	0025	0035	0045	0055
Liverpool St Station *Bus Station* ⊖ ⇌	0027	0047	0107	0127	0147	0207	0227		57	27		0457	0527	0557	0027	0037	0047	0057
Bethnal Green Station ⊖	0035	0055	0115	0135	0155	0215	0235	Then	05	35		0505	0535	0605	0035	0045	0055	0105
Old Ford *Parnell Road*	0040	0100	0120	0140	0200	0220	0240	at	10	40		0510	0540	0610	0040	0050	0100	0110
Bow Bridge *Marshgate Lane*	0043	0103	0123	0143	0203	0223	0243	these	13	43		0513	0543	0613	0043	0053	0103	0113
Stratford *Bus Station* ⊖ ⇌ *DLR*	0047	0107	0127	0147	0207	0227	0247	mins	17	47	until	0517	0547	0617	0047	0057	0107	0117
Leytonstone *Thatched House*	0051	0111	0131	0151	0211	0231	0251	past	21	51		0521	0551	---	0051	---	0111	0121
Leytonstone *Green Man*	0056	0116	0136	0156	0216	0236	0256	each	26	56		0526	0556	---	0056	---	0116	0126
Wanstead Station ⊖	0058	0118	0138	0158	0218	0238	0258	hour	28	58		0528	0558	---	0058	---	0118	0128
Snaresbrook *Hermon Hill*	0101	---	↓	0201	0221	↓	0301		↓	01		↓	0601	---	0101	---	---	0131
South Woodford *George Lane* ⊖	0104	---	↓	0204	0224	↓	0304		↓	04		↓	0604	---	0104	---	---	0134
Woodford Wells *Horse and Well*	0110	---	↓	0210	0230	↓	0310		↓	10		↓	0610	---	0110	---	---	0140
Redbridge Station ⊖	---	---	0142	---	---	0242	---		32	--		0532	---	---	---	---	---	---
Gants Hill Station ⊖	---	---	0146	---	---	0246	---		36	--		0536	---	---	---	---	---	---
Newbury Park Station ⊖	---	---	0150	---	---	0250	---		40	--		0540	---	---	---	---	---	---

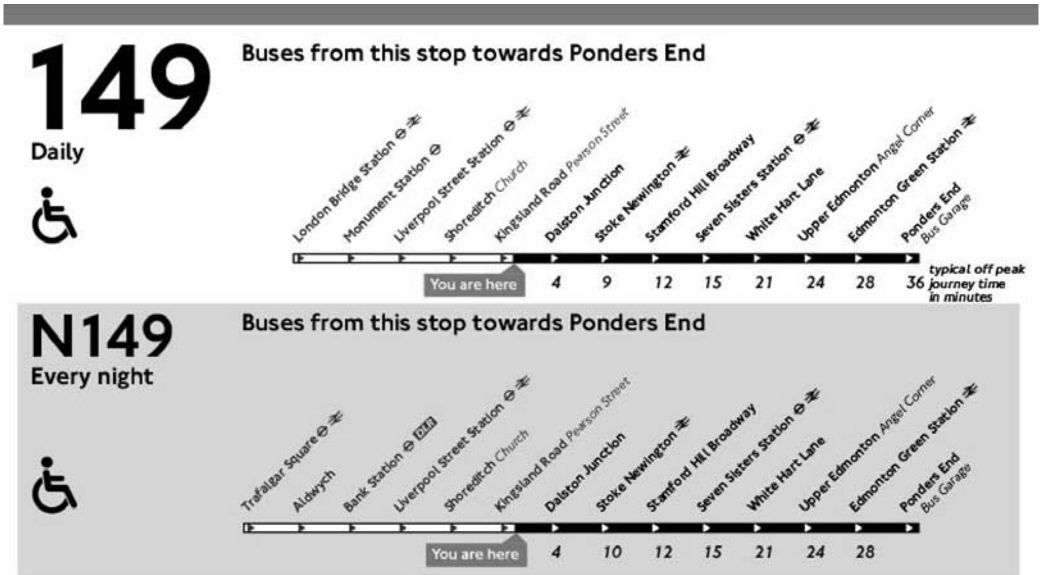
Friday night/Saturday morning and Saturday night/Sunday morning - contd

Victoria Station ⊖ ⇌	0035	---	0055	---	0120	0135	---	0155		--	25	--	55		0425	---	0455	---	0525
Hyde Park Corner ⊖	0038	---	0058	---	0123	0138	---	0158		--	28	--	58		0428	---	0458	---	0528
Oxford Circus ⊖	0046	0056	0106	0121	0131	0146	0156	0206		21	36	51	06		0436	0451	0506	0521	0536
Holborn Station ⊖	0058	0108	0118	0133	0143	0158	0208	0218		33	48	03	18		0448	0503	0518	0533	0548
Bank Station ⊖ *DLR*	0105	0115	0125	0140	0150	0205	0215	0225		40	55	10	25		0455	0510	0525	0540	0555
Liverpool St Station *Bus Station* ⊖ ⇌	0107	0117	0127	0142	0152	0207	0217	0227		42	57	12	27		0457	0512	0527	0542	0557
Bethnal Green Station ⊖	0115	0125	0135	0150	0202	0215	0225	0235	Then	50	05	20	35		0505	0520	0535	0550	0605
Old Ford *Parnell Road*	0120	0130	0140	0155	0205	0220	0230	0240	at	55	10	25	40		0510	0525	0540	0555	0610
Bow Bridge *Marshgate Lane*	0123	0133	0143	0158	0208	0223	0233	0243	these	58	13	28	43		0513	0528	0543	0558	0613
Stratford *Bus Station* ⊖ ⇌ *DLR*	0127	0137	0147	0202	0212	0227	0237	0247	mins	02	17	32	47	until	0517	0532	0547	0602	0617
Leytonstone *Thatched House*	0131	0141	0151	0206	0216	0231	0241	0251	past	06	21	36	51		0521	0536	0551	---	---
Leytonstone *Green Man*	0136	0146	0156	0211	0221	0236	0246	0256	each	11	26	41	56		0526	0541	0556	---	---
Wanstead Station ⊖	0138	0148	0158	0213	0223	0238	0248	0258	hour	13	28	43	58		0528	0543	0558	---	---
Snaresbrook *Hermon Hill*	↓	---	0201	---	0226	↓	---	0301		--	↓	--	01		↓	---	0601	---	---
South Woodford *George Lane* ⊖	↓	---	0204	---	0229	↓	---	0304		--	↓	--	04		↓	---	0604	---	---
Woodford Wells *Horse and Well*	↓	---	0210	---	0235	↓	---	0310		--	↓	--	10		↓	---	0610	---	---
Redbridge Station ⊖	0142	---	---	---	---	0242	---	---		--	32	--	--		0532	---	---	---	---
Gants Hill Station ⊖	0146	---	---	---	---	0246	---	---		--	36	--	--		0536	---	---	---	---
Newbury Park Station ⊖	0150	---	---	---	---	0250	---	---		--	40	--	--		0540	---	---	---	---

A - Starts from **Tottenham Court Road** at 0023.

London Travel Information 020 7222 1234 Operated by **Stagecoach** for London Buses, London SW1W 9TN 24.9.01 T3527T

Figure 87. Bus timetable for Route 8 in London.



Monday - Friday

First buses	6 to 7am	7 to 8am	8am to 8pm	8pm to midnight	Last buses	N149
0511	0604	0705	about every	about every	0004	Night buses
0526	0616	0715	5-8	8-10	0014	run every
0540	0628	0725	minutes	minutes	0024	hour
0552	0641	0732			0034	from 0140
	0654	0738			0044	to 0440
		0746			0054	
		0753				

Saturday

First buses	6 to 8am		8 to 9am	9am to midnight	Last buses	N149
0511	At these	16	0817	about every	0004	Night buses
0536	minutes	37	0829	7-10	0014	run every
0556	past the	57	0841	minutes	0024	hour
	hour		0853		0034	from 0141
					0044	to 0441
					0054	

Sunday and Public Holidays

First bus	6 to 7am	7 to 8am	8 to 9am	9 to 10am	10am to midnight	Last buses	N149
0511	0611	0701	0801	0903	about every	0004	Night buses
		0721	0818	0918	8-10	0014	run every
		0741	0833	0931	minutes	0024	hour
			0848	0941		0034	from 0140
				0951		0044	to 0440
						0054	

01.09.01 2104

LONDON London Travel Information 020 7222 1234 24 hours Textphone 020 7918 3015 Operated by Arriva London North Limited for London Buses

Figure 88. Stop-specific timetable for Kingsland Road Stop and Route 149.

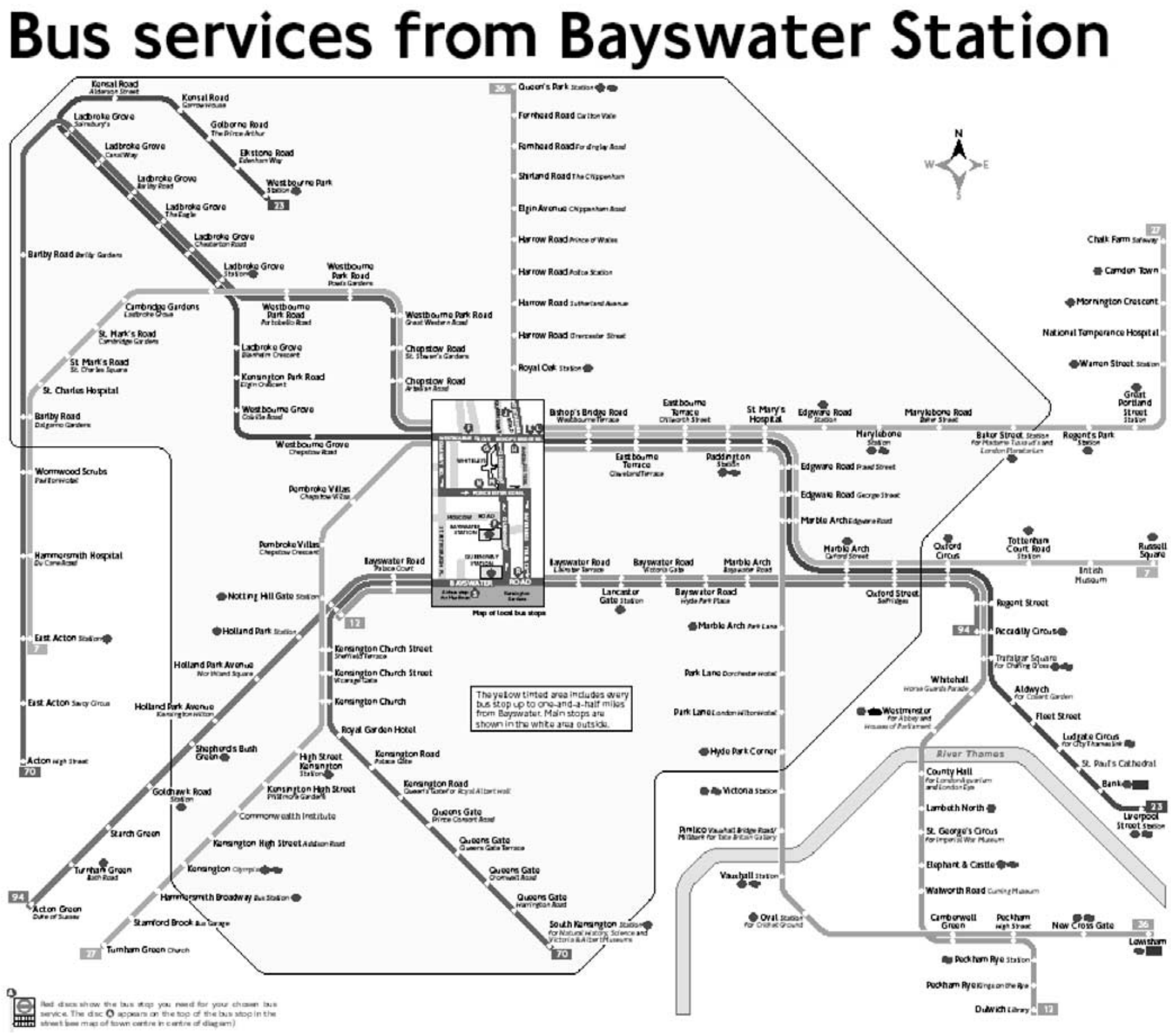


Figure 89. Spider map for bus service radiating from Bayswater Station in London.

to speak their responses to the itinerary-building questions, which are identical to those asked on the web application. The use of such voice technology provides access to trip and itinerary planning 24 hours per day, 7 days per week and does not require Internet access. Several other systems across the United States are now implementing this technology, including the Ann Arbor Transit Authority in Ann Arbor, Michigan. International deployments of IVR to provide TTI include the greater Sydney area in Australia (i.e., the Transport Infoline).

In addition to availability to TTI 24 hours per day, 7 days per week, voice-enabled technology can provide additional benefits to agencies, benefits that significantly improve the provision of TTI. These benefits include the capability to handle increased call volume, a reduction in call volume to customer service agents, and a reduction in the number of calls abandoned.

8.4 PROVISION OF REAL-TIME INFORMATION

Throughout this report, numerous examples of real-time information systems have been provided. Since the success of these and other similar systems deployed around the world has been discussed already, it would be helpful to view the addition of real-time information to TTI in a slightly different manner: from a planning perspective. The case of Oregon DOT's (ODOT's)Transit Trip Planning system illustrates the careful thinking required when considering, designing, and deploying a comprehensive TTI. The addition of real-time information, which is not a trivial element of a TTI, must be well planned out. ODOT conducted a study to determine the best approach to developing and deploying a comprehensive, statewide transit trip-planning system. ODOT's vision for this system is to "provide the public with seamless access to public transit information and services" (*16*). The outcome of this study was a recommendation to design and implement such a system in three phases (*17*):

- Phase 1: Design and implement a web-based clearinghouse;
- Phase 2: Add an automated trip-planning element; and
- Phase 3: Add long-term functionality, such as *real-time transit information,* and develop universal payment methods.

In October 2002, ODOT began the development of the transit trip planner. The key features of each release (which corresponds to each recommended phase) are as follows (*18*):

- Release 1 features:
  - Interactive tools to locate appropriate service provider(s) (e.g., map-based interface);
  - Public/private transit service providers directory;
  - Comprehensive transit data for each of the transit providers;
  - Links to sites with useful content; and
  - Other information, such as service area boundaries for each provider, bike maps and trails, and key landmarks and activity locations.
- Release 2 features:
  - Ability to automatically generate custom trip itinerary based on the user-specified parameters,
  - Provision of dynamic mapping support,
  - Support of transit information dissemination through various means,
  - Allowance for specialized automated queries to locate transit services, and
  - Provision of system usage statistics and travel patterns to support better transit planning.

Release 1 will be built on the existing ODOT TripCheck^{SM} system (www.tripcheck.com/), which provides statewide traveler information.

ODOT's approach to building a transit trip planning system is also exemplary because it is designed to address each of the following challenges (*19*):

- A comprehensive listing of transit schedules and other forms of public transportation options are not currently accessible in a seamless, centralized location;
- Transit schedules currently managed by ODOT's TripCheck website are dependent on several internal manual processes, affecting the timeliness of changes and reducing the accuracy of schedule data;
- A majority of transportation providers in the state do not have schedule or contact information electronically via the Internet; and
- The public has no way to easily obtain transportation options for trips within Oregon.

As noted earlier, the addition of real-time information is not considered until Phase 3 of the project. This will ensure that all other features of the system are fully operational and that the public has gotten accustomed to and has a certain level of confidence in using the system. Again, this is unlike many other systems that have introduced real-time information, not as part of an integrated TTI, but as a stand-alone element.

Another good example of introducing real-time information is the 5T system in Turin, Italy, which was discussed in Section 5.2. The 5T system, which has a clear public transport focus, provides real-time information as one of the elements of its TTI services. A customer can easily plan a journey and then check the real-time status of the vehicle(s) he or she would like to take.

The ultimate TTI would combine the real-time information on vehicle status with a trip plan. This has not yet been accomplished, but several TTI systems are striving to make improvements that have features as powerful as that. (e.g., WMATA's RideGuide). As of February 2003, FTA, FHWA, and the ITS Joint Program Office are in the early stages of planning a demonstration program that links real-time information with multimodal trip planning so that customers can obtain door-to-door real-time trip information.

8.5 REFERENCES AND ENDNOTES FOR SECTION 8

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

5T Telematics Technologies for Transport and Traffic in Turin (Italy)

AC Transit Alameda–Contra Costa Transit District
ADA Americans with Disabilities Act
AIGLE Aide à l'Intervention Globale sur les Lignes en Exploitation
AIP Automated itinerary planner
APTA American Public Transportation Association
APTS Advanced Public Transportation Systems
ARDIS Advanced Radio Data Information Service
ATC Azienda Trasporti Consorziali, Bologna, Italy
ATIS Advanced traveler information system
ATLANTIC A Thematic Long-term Approach to Networking for the Telematics and ITS Community
ATTAIN Advanced Traffic and Travel Information (System)
ATSCS Automatic Traffic Surveillance and Control System
AVL Automatic vehicle location

BART Bay Area Rapid Transit, San Francisco
BLIS Bus Location and Information System

CAD Computer-aided dispatch
Caltrans California DOT
CCRTA Cape Cod (Massachusetts) Regional Transit Authority
CCVIP Computer Center for Visually Impaired People, Baruch College, New York
CDPD Cellular digital packet data
COTA Central Ohio Transit Authority
CRM Customer relationship management
CTA Chicago Transit Authority
CUE City-University-Energysaver, Fairfax, Virginia

DGPS Differential global positioning system
DMS Dynamic message sign
DOM De Orientierte Mensch (The Oriented Person)
DOT Department of Transportation
DRS Demand-responsive system
DSRC Dedicated short-range communications
DTMF Dual-tone multifrequency

EDAPTS Efficient Development of Advanced Public Transportation Systems
EFA Elektronische Fahrplanauskunft
ELMI Espoo and Länsiväylä Passenger Information System, Helsinki
ETA Estimated time to arrival

FedEx Federal Express
FIT Fixed information terminal
FHWA Federal Highway Administration
FOT Field operational test
FTA Federal Transit Administration

GIS Geographic information systems
GPS Global positioning system
GSM Global system for mobile communications
HELMI Helsinki City Transport's real-time information system for both bus and train lines

IP Internet protocol
ISDN Integrated Services Digital Network
ISP Information service provider
ITH Illinois Transit Hub
ITS Intelligent Transportation Systems
ITSA Intelligent Transportation Society of America
IVR Interactive voice response

JPO Joint Program Office

LACMTA Los Angeles County Metropolitan Transportation Authority
LADOT Los Angeles DOT
LAN Local-area network
LED Light-emitting diode
LIRR Long Island Rail Road, New York

MAX Metropolitan Area Express (Portland)
MDT Mobile data terminal
MMDI Metropolitan Model Deployment Initiative
MMTIS Multi-Modal Traveler Information System
MOBINET Mobilität im Ballungsraum München
MTA Metropolitan Transportation Authority, New York
MTC Metropolitan Transportation Commission
MUNI San Francisco Municipal Railway
MVV Münchner Verkehrs und Tarifverbund

NTCIP National Transportation Communications for ITS Protocol

ODOT Oregon DOT
OSU Ohio State University
OVR OV reisinformatie (The Netherlands)

PDA Personal digital assistant
PIDS Passenger information display system
PIEPSER Personalized Information on Disruptions to Public Transport Exclusive to Users of Public Transport
PIS Passenger Information System
PROMISE Personal Mobile Traveler and Traffic Information Service
PTA Personal traveler assistant
PTDB Public transport database
PTI Public transport information

RATP Régie Autonome des Transports Parisiens
RER RATP's Regional Rail Service
RISS Remote infrared signage system
RTA Regional Transportation Authority, Chicago
RTD Regional Transportation District, Denver

SEPTA Southeastern Pennsylvania Transportation Authority
SIEL System D'Information en Ligne
SIS Service Information System
SLO San Luis Obispo (Transit)
SMS Short message service
SNCF Société Nationale des Chemins de Francais (France)
STCUM Société de Transport de la Communauté Urbaine de Montréal
STIB Société des Transports Intercommunaux de Bruxelles
SWM Stadtwerke Munich

TARS Travelers Advisory Radio System
TATS Traveler Advisory Telephone System
TCIP Transit Communications Interface Profile
TCP Transfer connection protection
TCRP Transit Cooperative Research Program
TDDS Talking Directory Display System
TEN Trans-European Networks
TIC Traffic Information Center
TIS Traveler Information System
TMC Transportation Management Center
TRACKER Collective technologies used by TRIO
TRB Transportation Research Board
TRIDENT TRansport Intermodality Data sharing and Exchange NeTwork
Tri-Met Tri-County Metropolitan Transportation District, Portland, Oregon
TRIO Tri-State Advanced Rural Traveler Information System of Maine, New Hampshire, and Vermont
TRIS Transportation Research Information Services
TTI Transit traveler information
TTS Text-to-speech

UDOT Utah DOT
UML Unified Modeling Language
UPS United Parcel Service
UTA Utah Transit Authority

VCTC Ventura County (California) Transportation Commission
VIA Visualizzazione Informazioni Arrivi, Turin
VMS Variable message sign
VRE Virginia Railway Express
VRR Verkehrsverbund Rhein-Ruhr
VSCS Vehicle Scheduling and Control System

WAP Wireless application protocol
WAW Wide-area wireless
WLAN Wireless local area network
WMATA Washington Metropolitan Area Transit Authority
WSF Washington State Ferries
WWW World Wide Web

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation