Preliminary Investigation (PI-0249)

Caltrans Division of Research, Innovation and System Information

Innovative Technology to Improve Transit Services for Disabled Travelers

Requested by
Nellie Almazan, Division of Mass Transportation

June 17, 2020

The Caltrans Division of Research, Innovation and System Information (DRISI) receives and evaluates numerous research problem statements for funding every year. DRISI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field. The contents of this document reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the California Department of Transportation, the State of California, or the Federal Highway Administration. This document does not constitute a standard, specification, or regulation. No part of this publication should be construed as an endorsement for a commercial product, manufacturer, contractor, or consultant. Any trade names or photos of commercial products appearing in this publication are for clarity only.

Table of Contents

Executive Summary

Background

The California Department of Transportation (Caltrans) is interested in learning more about the technologies available to assist travelers with sensory impairments or disabilities and other customers covered under the Americans With Disabilities Act of 1990 (ADA) to get from their origins to destinations (first mile/last mile to public transportation). These technologies are expected to be part of a comprehensive program of transit services that improve the independent mobility of travelers with disabilities and increase ridership on trains, buses and light rail.

To assist Caltrans in this information-gathering effort, CTC & Associates conducted a literature search that identified publicly available resources describing current applications and future initiatives associated with technology designed to improve services and outreach for community members and other travelers with disabilities seeking to use transit services. Supplementing these findings are the results of an online survey of California's 18 metropolitan planning organizations (MPOs) and 10 MPOs serving large urban areas outside California that sought information about current practices and planned enhancements to the technologies designed to assist disabled users of transit services. Survey respondents also included three people representing advocacy organizations for disabled populations in California.

Summary of Findings

This Preliminary Investigation gathered information in two areas:

- Related research and resources.
- Survey of practice.

Related Research and Resources

The tables beginning on page 4 summarize the publications, research in progress and other resources highlighted in this Preliminary Investigation in these topic areas:

- Accessible Transportation Technologies Research Initiative:
    - Policies.
    - Assistive technologies.
- Serving travelers with a range of disabilities:
    - National research and resources.
    - State research and resources.
    - Related resources.
- Serving visually impaired travelers:
    - National research and resources.
    - State research and resources.
    - Smartphone and other applications.
    - Indoor navigation.
    - Indoor/outdoor navigation.
- Enhancing transit facilities.

Each table provides the publication or project title, the year of publication (research in progress is noted without a year) and an excerpt from the publication's abstract or a brief description of the resource. Some tables also provide the type of resource (such as national, state or vendor web site). More detail about each publication can be found in the **Detailed Findings** section of this report.

Gaps in Findings

The survey conducted for this project received an extremely limited response, with few respondents providing the type of information sought by the project panel. Reaching out directly to transit agencies not participating in the survey could uncover useful information about other agencies' experience.

Next Steps

Moving forward, Caltrans could consider:

- Examining in detail selected publications cited in this Preliminary Investigation to learn more about the types of assistive technologies in development or being piloted by transit agencies around the country.
- Engaging with the California transit agencies responding to the current survey to learn more about those agencies' current practices and plans for the future, including:
    - Modesto Area Express' plans to provide an app for its paratransit operation that will track a vehicle, allow trip requests, pay for the trip, review upcoming and past trips, and provide alerts.
    - Roseville Transit's new service to allow passengers within the South Placer County region to request trip reservations and self-manage their trips online.
    - Mandatory training programs for Modesto Area Express and Roseville Transit staff. These programs include sensitivity training to help staff communicate with travelers with disabilities. Learning how these training programs address disability discrimination and ADA training-related requirements would be useful.
- Conducting a follow-up survey that specifically targets a select group of other California transit agencies to learn more about current practices and future plans to use assistive technologies to meet the needs of California travelers with disabilities.
    - Consider including in this inquiry an examination of the funding required by transit agencies for the infrastructure and staff training needed to meet the needs of disabled travelers.

Accessible Transportation Technologies Research Initiative

Publication or Project (Year)	Excerpt From Abstract or Description of Resource
Accessible Transportation Technologies Research Initiative (ATTRI)	Describes ATTRI, a federal initiative charged with "identifying user needs of travelers with disabilities to develop new transformative applications to increase personal mobility." The ATTRI project serves three targeted populations: persons with disabilities, veterans with disabilities and older adults. Researchers are considering vision, mobility, hearing and cognitive disabilities as they conduct research and develop new tools and services.
ATTRI Institutional and Policy Issues Assessment Summary Report (2017)	Identifies and analyzes the policy, institutional and legal issues that are hindering development and deployment of advanced technologies with potential to improve mobility for people with disabilities.
Smart Wayfinding and Navigation System Using High Accuracy 3D Location Technology (2019)	Describes the Smart Wayfinding and Navigation (SWaN) service that delivers the underlying location and routing capabilities required to provide travelers with real-time location and en-route assistance and situational awareness, including within complex urban transport structures.
Accessible Transportation Technologies Research Initiative (ATTRI): Assessment of Relevant Research (2017)	Reports on research technologies within and outside of the transportation domain that show promise at addressing challenges facing ATTRI stakeholders.
Accessible Transportation Technologies Research Initiative (ATTRI): Innovation Scan (2017)	Describes results of an innovation scan to survey technologies recently introduced to public use that are being evaluated for effectiveness in select test markets prior to deployment at larger scales.
ATTRI State of Practice, Innovation and Assessment of Research Webinar (2016)	Provides a summary of the ATTRI program.

Serving Travelers With a Range of Disabilities: National and State Research and Resources

Publication or Project (Year)	Type of Resource	Excerpt From Abstract or Description of Resource
Transit IDEA J-04/IDEA 91: Comprehensive Wayfinding for All (CWall) (Research in Progress)	National	Expected to develop and test a prototype smartphone app that will provide transit and pedestrian trip planning and navigation assistance along the entire transit trip. Completion date: Spring 2020.
SMART Wayfinding System: System and Subsystem Requirements (2019)	National	Describes the SMART Wayfinding Specification that is expected to provide a de facto standard for cognitively accessible wayfinding apps that will provide a well-defined specification for developers to promote cross-platform use of routes created for one system with those created for other systems.
The Complete Trip: Helping Customers Make a Seamless Journey (2016)	National	Introduces the concept of the "complete trip"—from planning and booking the trip to paying for and embarking on the journey to negotiating the physical infrastructure (for example, sidewalks, street crossings) associated with the trip.

Publication or Project (Year)	Type of Resource	Excerpt From Abstract or Description of Resource
TCRP Report 163: Strategy Guide to Enable and Promote the Use of Fixed-Route Transit by People With Disabilities (2014)	National	Includes results of a nationwide survey of almost 2,000 people with disabilities that identified the main factors that affect their use of fixed-route transit services.
TCRP Web-Only Document 59: Using Pictograms to Make Transit Easier to Navigate for Customers With Communication Barriers (2012)	National	Describes research that assessed a set of 10 original pictograms designed to capture transit drivers' messages. Findings prove that pictograms can be effective, but also suggest that further research is required to identify universal images that would convey the messages transit drivers consider most important.
Improving Pathways to Transit for Persons With Disabilities (2016)	State: California	Explores, through case study work, efforts that have been effective in improving pathways to transit. Interviews and site visits were conducted with five transit agencies and partners actively engaged in improving pathways to connect transit consumers—particularly people with disabilities—with transit stations and stops.
Travel Assistance Device (TAD) (undated)	State: Florida	Describes Travel Assistance Device, a mobile application for GPS-enabled cellphones that helps new transit riders navigate the public transportation system.
INIT Announces Mobility Assistance App for Visual, Hearing and Mobility Impaired Riders (2020)	Smartphone and other applications	Describes the ASSISTIVEtravel app that offers personalized ride-hailing assistance and journey guidance for riders with visual, hearing and mobility impairments.
Public Transportation: An Investigation of Barriers for People With Disabilities (2017)	User needs	Presents results of an online survey that highlight significant barriers for people with disabilities who use public transportation and complementary paratransit services.
There's an App for That: Apps Help Mobility Management Professionals Empower Their Customers (2014)	Smartphone and other applications	Explores current smartphone transportation apps, with a particular focus on apps that support the travel of people with disabilities, older adults and people with limited income.

Serving Visually Impaired Travelers: National and State Research and Resources

Publication or Project (Year)	Type of Resource	Excerpt From Abstract or Description of Resource
Assistive Technologies for Visually Impaired Persons (2015)	National	Discusses development of a navigation aid that tracks the location of a user anywhere, including areas where GPS is not available. System uses sensors in smartphones, combined with a small wearable accessory, to track the user's movements, infer map information and discover key sensor signatures as the user creates a route.
Transit Information Access for Persons With Visual or Cognitive Impairments (2015)	National	Describes a system that pushes information to a passenger's smartphone or tablet from Wi-Fi Access Points (APs). APs placed at bus stops and within bus vehicles are programmed to communicate with the user's smartphone through Wi-Fi.

Publication or Project (Year)	Type of Resource	Excerpt From Abstract or Description of Resource
RouteMe2: A Cloud-Based Infrastructure for Assisted Transit (2018)	State: California	Describes RouteMe2, a cloud-based system designed to facilitate use of public transit by those with difficulties traveling independently. Travelers or other authorized individuals (such as family members or caregivers) can register a trip using the web application.
A Public Transit Assistant for Blind Bus Passengers (2018)	State: California	Presents a prototype mobile application that communicates information via Wi-Fi access points installed in buses and at bus stops to help blind bus passengers reach their destination.
SFO [San Francisco International Airport] Unveils Mobile App for Visually-Impaired Passengers (2014)	State: California	Describes a prototype app that works in conjunction with approximately 500 beacons located throughout the airport terminal to audibly call out various points of interest, including gate boarding areas, restaurants and even power outlets.
Involving Individuals With Visual Impairment in Project Decision-Making: A Survey of Practice (2018)	State: Minnesota	Includes resources about assistive technologies for persons with visual impairment as well as designing transportation facilities for persons with visual impairment.
Capital Metro Tests App to Provide Real-Time Info to Blind Riders (2018)	State: Texas	Provides details of bus riders using the BlindSquare mobile app to receive real-time bus schedule and service alert information automatically when they are in proximity to the stop. A network of beacons delivers the information to the app.
What is BlindSquare? (undated)	Vendor web site	Describes BlindSquare as “the world’s most widely used accessible GPS-app developed for the blind and visually impaired. Paired with third-party navigation apps, BlindSquare’s self-voicing app delivers detailed points of interest and intersections for safe, reliable travel both outside and inside.”
Where’s My Bus Stop? Supporting Independence of Blind Transit Riders With StopInfo (2014)	State: Washington	Discusses the development and deployment of StopInfo, a system for public transit riders that provides detailed information about bus stops with the goal of helping riders find and verify bus stop locations. Internal information from a major Seattle area transit was augmented with information entered by the community.
Announcing StopInfo! (2014)	State: Washington	Describes StopInfo, a new service linked with OneBusAway for the Puget Sound region that provides detailed information about bus stops.
Milwaukee County Launches Pilot Program to Expand Accessibility for MCTS Riders (2020)	State: Wisconsin	Highlights the use of Aira, an app available on any iOS or Android smartphone, which provides Milwaukee County Transit System (MCTS) users with free, one-on-one assistance riding the bus and navigating the more than 5,000 bus stops in Milwaukee County.
The World Can Be Complex. Using Aira is Simple (2017-2018)	Vendor web site	Describes Aira as “a service that connects blind and low-vision people to highly trained, remotely-located agents. Through an app on your smartphone, Aira delivers instant access to visual information at the touch of a button ….”

Publication or Project (Year)	Type of Resource	Excerpt From Abstract or Description of Resource
MBTA Launches AccessAI Pilot Connecting Blind and Low Vision Users With Aira's Human Artificial Intelligence Technology (2019)	State: Massachusetts	Announces the Massachusetts Bay Transportation Authority (MBTA) launch of a free six-month accessibility technology pilot called AccessAI that features Aira technology. The MBTA system connects blind or low-vision users with highly trained sighted agents who provide visual information about the user's surrounding environment—live and on-demand through smartphone video technology.
MTA NYC to Offer Free Access to Aira (2019)	State: New York	Announces a three-month pilot by the New York City Metropolitan Transportation Authority (NYC MTA) to offer Aira services. Using a smartphone—or a pair of Aira's proprietary Horizon Smart Glasses—an Aira user connects to a remote professional agent, who can see the user's surroundings through the camera of the user's device.

Serving Visually Impaired Travelers: Smartphone and Other Applications

Publication or Project (Year)	Excerpt From Abstract or Description of Resource
GPS and Wayfinding Apps (2020)	Offers a list of applications for mobile devices that can aid people with visual impairments in finding destinations. The apps listed are for use in conjunction with white canes and service animals, not to replace them.
Mobility Technologies for Blind, Partially Sighted and Deafblind People: Design Issues (2017)	Provides an overview of the factors to be considered in the design of travel aids that meet the needs of disabled travelers, including specific principles of good design practice; app design; end-user involvement; and particular features such as functionality, the interface, sensors, privacy and context awareness.
Feasibility of Using Haptic Directions Through Maps With a Tablet and Smart Watch for People Who are Blind and Visually Impaired (2016)	Describes two prototypes designed to test users' ability to trace graphical lines and directions through maps on a touchscreen using haptic feedback from an Android smartwatch and tablet.
Incorporating Information From Trusted Sources to Enhance Urban Navigation for Blind Travelers (2015)	Presents the NavPal suite of technology tools, which includes a dynamic guidance tool in the form of a smartphone app that can provide real-time instructions based on available map information to guide navigation in indoor environments.
Enhancing the Safety of Visually Impaired Travelers In and Around Transit Stations (2014)	Describes a set of design guidelines for useful technology and a prototype of an accessible smartphone tool that allows travelers to annotate their paths and choose/invite trusted sources to enhance the relevant information that can enhance the safety and efficacy of their travel.
Enhancing Independence and Safety for Blind and Deaf-Blind Public Transit Riders (2011)	Describes GoBraille, two related Braille-based applications that provide information about buses and bus stops. GoBraille is built on MoBraille, a novel framework that enables a Braille display to benefit from many features in a smartphone.

Serving Visually Impaired Travelers: Indoor Navigation

Publication or Project (Year)	Excerpt From Abstract or Description of Resource
Indoor Navigation by People With Visual Impairment Using a Digital Sign System (2013)	Describes development and testing of a digital sign system. The system includes digitally encoded signs widely distributed throughout a building, a handheld sign reader based on an infrared camera, image-processing software and a talking digital map running on a mobile device.
PERCEPT Indoor Navigation System for the Blind and Visually Impaired: Architecture and Experimentation (2012)	Presents the PERCEPT system, which provides enhanced perception of the indoor environment using passive radio frequency identification (RFID) tags deployed in the environment, a custom-designed handheld unit and smartphone carried by the user, and PERCEPT server that generates and stores the building information and the RFID tags deployment.
The User as a Sensor: Navigating Users With Visual Impairments in Indoor Spaces Using Tactile Landmarks (2012)	Describes Navatar, an indoor navigation system that allows for localization and navigation by exploiting the physical characteristics of indoor environments, taking advantage of the unique sensing abilities of users with visual impairments, and minimalistic sensing achievable with low-cost accelerometers available in smartphones.

Serving Visually Impaired Travelers: Indoor/Outdoor Navigation

Publication or Project (Year)	Excerpt From Abstract or Description of Resource
Seamless Wayfinding by Individuals With Functional Disability in Indoor and Outdoor Spaces: An Investigation Into Lived Experiences, Data Needs and Technology Requirements (Research in Progress)	Expected to use a mixed-method design to develop a saliency feature inventory for supporting effective wayfinding design for individuals with visual impairments, blindness and deafblindness in urban environments. Completion date: December 2020.
Technological Trends in Improved Mobility of the Visually Impaired (2020)	Examines topics including, but not limited to, obstacle detection systems, indoor and outdoor navigation, transportation sustainability systems and hardware/devices to aid visually impaired people.
Comparing Tactile to Auditory Guidance for Blind Individuals (2019)	Describes researchers' exploration of the efficacy of a tactile navigational aid that provides turn signals via vibrations on a hip-worn belt.
Building Smart Transportation Hubs With 3D Vision and Video Technologies to Improve Services to People With Disabilities (2017)	Describes the design and development of a novel cyber-physical infrastructure that can transform existing transportation hubs into smart facilities capable of providing better location-aware services (e.g., finding terminals, improving travel experience, obtaining security alerts).
Navigating With a Visual Impairment: Problems, Tools and Possible Solutions (2016)	Discusses notable examples of navigational aids for people who have a visual impairment, along with the advantages and disadvantages of each. Classifies navigational technologies according to the mode of accommodation and type of sensor used to collect environmental information.

Publication or Project (Year)	Excerpt From Abstract or Description of Resource
Improving Public Transit Accessibility for Blind Riders by Crowdsourcing Bus Stop Landmark Locations With Google Street View: An Extended Analysis (2015)	Introduces and evaluates a new scalable method for collecting bus stop location and landmark descriptions by combining online crowdsourcing and Google Street View.
Improving Transit Facility Accessibility by Employing Wayfinding Technology (2011)	Focuses on identifying new technologies that improve accessibility within transit systems, especially for customers who are blind or have visual impairments and use wayfinding to navigate.
WeWALK Smart Cane (undated)	Describes an electronic cane designed to make the walking experience for blind and low-vision community members easier.

Enhancing Transit Facilities

Publication or Project (Year)	Excerpt From Abstract or Description of Resource
Impact of Bus Stop Improvements (2018)	Analyzes recent bus stop improvements made by the Utah Transit Authority to determine whether, and to what extent, the improvements are associated with changes in stop-level ridership and demand for paratransit service in the areas immediately surrounding improved bus stops.
Access to Urban Transportation System for Individuals With Disabilities (2017)	Reviews current practices and guidelines for accessible design of transportation, both access to and within transport facilities, based on information from the United States, United Kingdom and Hong Kong.

Detailed Findings

Background

The California Department of Transportation (Caltrans) is interested in learning more about the technologies available to assist travelers with sensory impairments or disabilities and other customers covered under the Americans With Disabilities Act of 1990 (ADA) to get from their origins to destinations (first mile/last mile to public transportation). These technologies are expected to be part of a comprehensive program of transit services that improve the independent mobility of travelers with disabilities and increase ridership on trains, buses and light rail.

To assist Caltrans in this information-gathering effort, CTC & Associates conducted a literature search that identified publicly available resources that describe current applications and future initiatives associated with technology designed to improve services and outreach for community members and other travelers with disabilities seeking to use transit services. Supplementing these findings are the results of an online survey of California's 18 metropolitan planning organizations (MPOs), an additional 10 MPOs serving large urban areas outside California and three people representing advocacy organizations for disabled populations in California. The survey sought information about current practices and planned enhancements to the technologies designed to assist disabled users of transit services. Findings from these efforts are presented in this Preliminary Investigation in two areas:

- Related research and resources.
- Survey of practice.

Related Research and Resources

A literature search of domestic in-progress and completed research examined the technologies and practices that might be used by transit providers or transit users to improve services to travelers with disabilities. Findings from this examination of publicly available resources are organized into the following topic areas:

- Accessible Transportation Technologies Research Initiative:
    - Policies.
    - Assistive technologies.
- Serving travelers with a range of disabilities:
    - National research and resources.
    - State research and resources.
    - Related resources.
- Serving visually impaired travelers:
    - National research and resources.
    - State research and resources.
    - Smartphone and other applications.
    - Indoor navigation.
    - Indoor/outdoor navigation.
- Enhancing transit facilities.

Accessible Transportation Technologies Research Initiative

Accessible Transportation Technologies Research Initiative (ATTRI) is a joint initiative of the U.S. Department of Transportation "co-led by the Federal Highway Administration (FHWA), Federal Transit Administration (FTA), and Intelligent Transportation Systems Joint Program Office (ITS JPO), with support from the National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR), and other federal partners."

A February 2016 webinar (cited on page 13) describes ATTRI as a multiyear, multimodal, multiagency research effort that was charged with "identifying user needs of travelers with disabilities to develop new transformative applications to increase personal mobility."

The ATTRI project serves three targeted populations: persons with disabilities, veterans with disabilities and older adults. Researchers are considering vision, mobility, hearing and cognitive disabilities as they conduct research and develop new tools and services. ATTRI's current technology research areas include:

- *Wayfinding and navigation*. Real-time information, localization and situational awareness to assist in navigating indoor and outdoor environments, including path planning and detouring around blocked routes or hazards.
- *Pre-trip concierge and virtualization*. Pre-trip planning and en-route travel information to travelers with disabilities, their family members and caregivers, including creating a virtual environment for users to familiarize themselves with their travel before the trip.
- *Safe intersection crossing.* Context-based information related to pedestrian and built environments delivered to pedestrians, who use their connected mobile devices to interface with vehicles, traffic signals and other infrastructure to receive this information.
- *Robotics and automation. C*ollaborative robots that not only assist with activities of daily life such as walking, but also work with individual travelers and human transportation services to provide related services at different points of travel.

The citations below are a sampling of the publications and resources available through the ATTRI web site.

Accessible Transportation Technologies Research Initiative (ATTRI), Intelligent Transportation Systems Joint Program Office, U.S. Department of Transportation, undated. https://www.its.dot.gov/research_areas/attri/index.htm
From the web site: The ATTRI Program is leading efforts to develop and implement transformative applications to improve mobility options for all travelers, particularly those with disabilities. With nearly 20 percent of the U.S. population comprising individuals with disabilities, and other demographic trends such as the increasing number of older Americans, USDOT [U.S. Department of Transportation] is seeking to expand innovative travel options. ATTRI research focuses on removing barriers to transportation for people with visual, hearing, cognitive and mobility disabilities. Emerging technologies and creative service models funded by ATTRI will offer all Americans enhanced travel choices and accessibility at levels once only imagined.
….

Complete Trip
Working together, the four technology areas [wayfinding and navigation, pre-trip concierge and visualization, safe intersection crossing, and robotics and automation] will provide the basis for an accessible transportation network that is far more economical, expansive and welcoming

than we have now, which is of increasing importance not only to travelers with disabilities, but to all travelers in the United States.

The accessibility of a transportation system can be described in terms of the ability of individuals to go from home to a destination without breaks or in terms of a travel chain with various links such as trip planning, travel to station, station/stop use, boarding vehicles, using vehicles, leaving vehicles, using the stop or transferring, and travel to destination after leaving the station or stop. If one link is not accessible, then access to a subsequent link is unattainable and the trip cannot be completed. Thus, the travel chain defines the scope of potential research and development in accessible transportation.

Policies

ATTRI Institutional and Policy Issues Assessment Summary Report, Scott Baker, Viktor Zhong, Jerry Hsu, Patricia Macchi, Shawn Kimmel, Lindsay Gladysz, Mohammed Yousuf, Candace Groudine and Kenneth Wood, U.S. Department of Transportation, February 2017.
https://rosap.ntl.bts.gov/view/dot/34721
From the abstract: The objective of this project is to identify and analyze the policy, institutional and legal issues that are hindering development and deployment of advanced technologies with potentials to improve mobility for people with disabilities. The major policy, institutional and legal issues identified include lack of awareness of disability needs among policy makers and technology developers, relatively weak research and development incentives due to the perception of lack of economic feasibility in the market of persons with disabilities, underutilized potential of Transportation Network Companies (TNCs) in providing paratransit services, inconsistent standards/regulations/laws across regions, and technology developers' concerns of liabilities and risks. A list of eight potential actions was proposed to address those issues. The proposed actions were evaluated and prioritized based on their travel and economic impacts and feasibility.

Assistive Technologies

Smart Wayfinding and Navigation System Using High Accuracy 3D Location Technology, Carol Politi, Carole Teolis, Travis Young, Sarah Blaszak and Jay Bracht, U.S. Department of Transportation, November 2019.
https://rosap.ntl.bts.gov/view/dot/44056
From the abstract: TRX [Systems, Inc.] developed a NEON Smart Wayfinding and Navigation (SWaN) service that delivers the underlying location and routing capabilities required to allow application developers to provide travelers with real-time location and en-route assistance and situational awareness, including within complex urban transport structures. These core indoor location and routing capabilities enable application developers to better support safe independent travel for people with a diverse set of abilities. … During this project, TRX extended an existing baseline location service (NEON) to support the requirements of accessible travelers. Key tasks included development of venue mapping and route creation tools, delivery of infrastructure-free and infrastructure-based location capabilities, and support for determination of a route through a complex transit structure with accessible constraints. … The core innovation was the development of a navigation and wayfinding mobile service with open APIs [application developer interfaces] for application developers delivering localization, orientation, waypoint navigation and route guidance. This document summarizes the developments and benchmark testing performed during this two-year project, including successful testing and validation in complex transit hubs in the [Washington, D.C.] metro.

Accessible Transportation Technologies Research Initiative (ATTRI): Assessment of Relevant Research, Joseph Andrew Giampapa, Aaron Steinfeld, Ermine Teves, M. Bernardine Dias and Zachary Rubinstein, U.S. Department of Transportation, April 2017.
http://ri.cmu.edu/wp-content/uploads/2017/04/3_ATTRI_ARR_2017-04.pdf
From the abstract: This report is one of three intended to provide an overview of technologies, innovations and research that are applicable to the ATTRI vision. The particular focus of this report is an Assessment of Relevant Research [ARR], to report on research technologies—both within and outside of the transportation domain—that show promise at addressing the challenges that face ATTRI stakeholders. While ARR technologies are discussed with a vision toward their application to ATTRI stakeholder transportation needs, they represent little or no direct public experiences with such technologies in the transportation context. The overall organization of this report echoes the organization of the overall ATTRI effort.

Accessible Transportation Technologies Research Initiative (ATTRI): Innovation Scan, Joseph Andrew Giampapa, Aaron Steinfeld, Ermine Teves, M. Bernardine Dias and Zachary Rubinstein, U.S. Department of Transportation, April 2017.
http://ri.cmu.edu/wp-content/uploads/2017/04/2_ATTRI_INNO_2017-04.pdf
From the abstract: The particular focus of this report is an Innovation Scan [INNO] to survey technologies that have been recently introduced to public use and are being evaluated for effectiveness in select test markets prior to deployment at larger scales. User experiences with INNO technologies either represent the segment of the test market user population or are based on reports by the organization that is introducing the technology.

ATTRI State of Practice, Innovation and Assessment of Research Webinar, U.S. Department of Transportation, February 2016.
https://www.its.dot.gov/research_archives/attri/pdf/ATTRI%20Innovation%20Research%20Webinar%20v6.pdf
This webinar provides a summary of the ATTRI program, including:

- Program progress:
  - State of practice scan.
  - Innovation scan.
  - Assessment of relevant research reports.
- Specific examples from accessible transportation or related fields of how the relevant methods, practices and technologies can meet the needs of transportation users of all abilities.
- Recommendations regarding key opportunities on emerging technologies relative to accessible transportation.
- Engaging stakeholders.

Serving Travelers With a Range of Disabilities

National Research and Resources

Project in Progress: Transit IDEA J-04/IDEA 91: Comprehensive Wayfinding for All (CWall), start date: August 2018; expected completion date: spring 2020.
Project description at http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4615
From the project description: This project will develop and test a prototype smartphone application (app) that will provide transit and pedestrian trip planning and navigation assistance

along the entire transit trip. The app, called Comprehensive Wayfinding for All (or CWall), will aid users in locating bus stops (bus stops will be equipped with Bluetooth low-energy beacons), traveling to stops using accessible pedestrian pathways, obtaining real-time transit information and receiving alerts for when to board and get off buses. Although CWall's intended audience is users with visual and mobility impairments, the app will also benefit users without disabilities by reducing the learning curve of taking transit and making the sidewalk and transit network easier to understand and use.

SMART Wayfinding System: System and Subsystem Requirements (Leveraging Innovative Technology to Develop the *SMART* Wayfinding Standard to Facilitate Independent Use of Public Transit by Individuals With Cognitive Disabilities), Daniel K. Davies and Steven E. Stock, Federal Highway Administration, August 2019.
https://rosap.ntl.bts.gov/view/dot/43629
From the abstract: The SMART Wayfinding Specification will provide a de facto standard for cognitively accessible wayfinding apps [that] will provide a well-defined specification for developers to promote cross-platform use of routes created for one system with those created for other systems. Specially designed methodologies are required to overcome cognitive limitations experienced by individuals with cognitive disabilities and others with limited ability to use mainstream travel tools to enable these individuals to independently travel by bus or other public transportation vehicle to their destination without assistance from others.

The Complete Trip: Helping Customers Make a Seamless Journey, National Center for Mobility Management, 2016.
https://nationalcenterformobilitymanagement.org/wp-content/uploads/2013/11/1_Complete_Trip_Final.pdf
From the introduction: This info brief introduces the concept of the "complete trip"—from planning and booking the trip to paying for and embarking on the journey to negotiating the physical infrastructure (e.g., sidewalks, street crossings) associated with the trip. It encourages mobility managers to anticipate potential stumbling blocks that may be encountered by the people they serve along the journey and to be proactive in assisting people in achieving a seamless trip.

TCRP Report 163: Strategy Guide to Enable and Promote the Use of Fixed-Route Transit by People With Disabilities, Russell Thatcher, Caroline Ferris, David Chia, Jim Purdy, Buffy Ellis, Beth Hamby, Jason Quan and Marilyn Golden, 2014.
Publication available at http://www.trb.org/Publications/Blurbs/170626.aspx
From the foreword: Following the Introduction, the *Strategy Guide* presents information on the current use of transit services—both fixed route and ADA complementary paratransit—by people with disabilities. It also presents the results of a nationwide survey of almost 2,000 people with disabilities that identified the main factors that affect their use of fixed-route transit services. This foundational information sets the stage for the critical steps and strategies that could be pursued by transit agencies seeking to better serve disabled people with fixed-route bus and rail transit services.

TCRP Web-Only Document 59: Using Pictograms to Make Transit Easier to Navigate for Customers With Communication Barriers, Jane Mobley and Deborah Matherly, September 2012.
Publication available at http://www.trb.org/Publications/Blurbs/168841.aspx
From the abstract: This report distills efforts that have gone into developing and implementing pictograms in a variety of settings, including transit, transportation, health, manufacturing and hospitality. It also analyzes a body of primary research from interviews with bus drivers and

operators who identified critical messages; experts who work with or serve people with communication challenges; and end users, passengers with communication challenges. The end users included people who were native English-speakers; who spoke little or no English; people who were deaf or hard of hearing; people with cognitive, sensory or physical disabilities; people who were over the age of 65; and people who were new to the transit system. Bus transit was selected to fit the limited scope of this study, although the conclusions reached can have applicability to other transit modes as well. Four transit agencies and their partner community service providers conducted pilot tests inside parked buses to assess a set of 10 original pictograms designed to capture the drivers' messages. The research proves that pictograms can be effective, but it also suggests that substantial study is yet to be done to identify universal images that would convey the messages transit drivers consider most important.

State Research and Resources

California

Improving Pathways to Transit for Persons With Disabilities, Stephanie DiPetrillo, Andrea Lubin, Anastasia Loukaitou-Sideris, Carla Salehian, Stephen Gibson, Kristen Williams and Theodore Trent Green, California Department of Transportation, August 2016.
https://transweb.sjsu.edu/sites/default/files/1233-transit-access-for-persons-with-disabilities.pdf
From the abstract: This research study explores, through case study work, efforts that have been effective in improving pathways to transit. Interviews and site visits were conducted with five transit agencies, along with their partners, that are actively engaged in improving pathways to connect transit consumers—particularly people with disabilities—with transit stations and stops. These agencies are: Broward County Transit (Broward County, FL), Memphis Area Transit Authority (Memphis, TN), NJ TRANSIT (Newark and New Brunswick, NJ), Tri-County Metropolitan Transportation District of Oregon (Portland, OR), and Link Transit (Wenatchee, WA). Promising practices and/or lessons were identified through the case study analysis; these should be considered by any transit agency seeking to create improved access to its services for persons with disabilities.

Florida

Travel Assistance Device (TAD), Location-Aware Information Systems Laboratory, University of South Florida, undated.
https://www.locationaware.usf.edu/ongoing-research/projects/travel-assistance-device/
From the web page: The Travel Assistance Device (TAD) is a mobile application for global positioning system (GPS)-enabled cellphones that helps new transit riders navigate the public transportation system. TAD prompts the rider in real-time with a recorded audio message (e.g., "Get Ready" and "Pull the Cord Now!"), visual images and vibration alerts when the rider should pull the stop request cord to exit the bus. Personalized trips are planned for each traveler using the TAD web page. Automated alarms can be triggered and the travel trainer and/or parent/guardian remotely alerted in case a rider wanders off their pre-determined path. Traditional phone communication is possible between the rider and the trainer allowing them to guide the rider to the correct location if they are lost.

Related Resources

"INIT Announces Mobility Assistance App for Visual, Hearing and Mobility Impaired Riders," *Mass Transit*, January 29, 2020.
https://www.masstransitmag.com/technology/passenger-info/mobile-applications/press-release/21123331/init-innovations-in-transportation-inc-init-announces-mobility-assistance-app-for-visual-hearing-and-mobility-impaired-riders
From the online article: A new app has been announced by Innovations in Transportation, Inc. (INIT) that offers personalized ride hailing assistance and journey guidance for riders with visual, hearing and mobility impairments. The ASSISTIVEtravel app aids impaired riders at all stages of their bus trip.

"Public Transportation: An Investigation of Barriers for People With Disabilities," Jill Bezyak, Scott Sabella and Robert Gattis, *Journal of Disability Policy Studies*, Vol. 28, Issue 1, pages 52-60, April 2017.
Citation at https://journals.sagepub.com/doi/full/10.1177/1044207317702070
From the abstract: The purpose of the current study was to provide a full description of barriers experienced by individuals with disabilities when using the public transportation and the complementary paratransit services. An online survey was developed and disseminated to contacts of the National Network of ADA Centers, and 4,161 individuals responded. Results highlight significant barriers for people with disabilities who use public transportation and complementary paratransit services. Barriers to these transit systems are physical and attitudinal in nature, and as a result, modifications to the physical environment and educational opportunities to reduce negative attitudes toward individuals with disabilities are recommended.

"There's an App for That: Apps Help Mobility Management Professionals Empower Their Customers," Information Brief, National Center for Mobility Management, 2014.
http://bit.ly/AppBrief
From the document: This brief explores current smartphone transportation apps, with a particular focus on apps that support the travel of people with disabilities, older adults and people with limited income. The brief concludes with a look at trending developments in future transportation apps.

Serving Visually Impaired Travelers

National Research and Resources

Assistive Technologies for Visually Impaired Persons, The Exploratory Advanced Research Program Fact Sheet, Federal Highway Administration, 2015.
https://www.fhwa.dot.gov/publications/research/ear/15040/15040.pdf
From the fact sheet: Another EAR [Exploratory Advanced Research] Program project investigating guidance solutions for visually impaired persons is "Navigation Guidance for People with Vision Impairment." This research project, conducted by TRX Systems, Inc., involves the development of a navigation aid that will be able to track the location of a user anywhere, including areas where GPS is not available. Such a tool will help to increase the mobility of people with vision disability by providing them spatial awareness for long-path planning and guidance. The system uses sensors in smartphones, combined with a small wearable accessory, to track the user's movements, infer map information, and discover key sensor signatures as the user creates a route. The system can store information from the ITS [intelligent transportation system] infrastructure that is accessible by standard smartphones with the route to facilitate use of public transportation systems. The researchers are also developing

tools that enable users to rate routes for difficulty and share routes with other users. Later, when a user wants to follow a saved route, the recorded route information can be used to provide audible or textual route guidance. In addition, the system can provide automated validation during transit that the user is on route or has reached a desired waypoint both indoors and outdoors.

Transit Information Access for Persons With Visual or Cognitive Impairments, Roberto Manduchi, Transit IDEA Project 71, Federal Highway Administration, July 2015.
http://onlinepubs.trb.org/onlinepubs/IDEA/FinalReports/Transit/Transit71.pdf
From the abstract: This project explored a novel approach to real-time, customizable, multi-modal travel-related information access for passengers with visual impairments or cognitive disabilities. In this system, information is pushed to a passenger's smartphone or tablet from Wi-Fi Access Points (APs). APs are placed both at bus stops and within bus vehicles. These APs are programmed to communicate with the user's smartphone through Wi-Fi, providing information that is then presented to the user in accessible form. In the prototype implementation, Wi-Fi APs are embodied in TP-LINK systems, running different types of server software, depending on whether the AP is placed at a bus stop or inside a bus vehicle. The APs communicate with a client application implemented in a tablet smartphone, operated by the user. The application communicates with the user via synthetic speech, with short sentences that convey information clearly and effectively. The user can input selections from menus by simple gestures such as screen taps and swipes. In addition, specific menus are triggered by a tap-and-hold gesture. The project team instrumented three bus stops and one bus vehicle in the University of California Santa Cruz campus. Four blind participants tested the system. User studies were supervised and recorded and each participant completed a semi-structured interview at the end of the study, which highlighted relevant accessibility issues with the current public transit system, recurring problems experienced by blind travelers, and perceived benefits and shortcoming of the proposed new technology.

State Research and Resources

California

"RouteMe2: A Cloud-Based Infrastructure for Assisted Transit," Alice Alvarado, Anthony Chong, Yusuke Kojitani, Elmer Orellana, Ethan Vadai, Lester Zhang, Germán Flores, Roberto Manduchi, Ethan Miller and Divyesh Jadav, *TRB 97th Annual Meeting Compendium of Papers*, Paper #18-01749, 2018.
https://escholarship.org/content/qt8wx760m2/qt8wx760m2.pdf?t=p06llv
From the abstract: The authors introduce RouteMe2, a cloud-based system that was designed to facilitate use of public transit by those who, due to visual or cognitive impairment, or old age, have difficulties traveling independently. RouteMe2 is comprised of a software infrastructure (including a cloud server, a web application and a mobile application) and a physical infrastructure for fine-grained localization at bus stops or at train platforms. In addition, RouteMe2 uses beacons placed inside bus vehicles and train cars, which allow for identification of an incoming vehicle. Travelers or other authorized individuals (family members, caregivers) can register a trip using the web application. The traveler may receive specific notifications, such as when he or she reaches a desired bus stop or a specific waiting/boarding area within the stop, or when the desired bus vehicle has arrived. Authorized individuals may also track the traveler's trip remotely using the web application, and be notified in case of problems (e.g., if the traveler has taken the wrong bus). A pilot implementation of RouteMe2 was completed at the UC Santa Cruz campus, with a demonstration of the most critical functionalities of the system.

Related Resource:

> **"A Public Transit Assistant for Blind Bus Passengers,"** Germán H. Flores and Roberto Manduchi, *IEEE Pervasive Computing*, Vol. 17, Issue 1, pages 49-59, January/March 2018. Citation at https://ieeexplore.ieee.org/document/8317998/
> *From the abstract*: Public transit is the key to independence for many blind persons but, despite recent progress in assistive technology, remains challenging for those without sight. To this end, the authors developed a prototype mobile application that communicates information via Wi-Fi access points installed in buses and at bus stops to help blind bus passengers reach their destination. A user study of the system yielded insights into general accessibility issues for blind public transit riders as well as ways to improve the proposed system.

"SFO Unveils Mobile App for Visually-Impaired Passengers," Press Release, San Francisco International Airport, July 31, 2014.
https://www.flysfo.com/media/press-releases/sfo-unveils-mobile-app-visually-impaired-passengers
While airports differ from land-based transit, this mobile application's underlying design may be of interest to transit providers. *From the press release*:

> San Francisco International Airport (SFO) today unveiled a prototype version of a smartphone application which can help visually-impaired passengers to navigate through an airport terminal. The app was developed through San Francisco Mayor Ed Lee's Entrepreneur-in-Residence Program, which paired SFO with the Indoo.rs, a leader in indoor navigation technology, and was developed in a relatively short span of 16 weeks. … The prototype app works in conjunction with approximately 500 beacons located throughout the terminal to audibly call out various points of interest, including gate boarding areas, restaurants and even power outlets. The prototype version will undergo additional testing and refinement before being released for use by the traveling public.

Minnesota

Involving Individuals With Visual Impairment in Project Decision-Making: A Survey of Practice, Transportation Research Synthesis, Minnesota Department of Transportation, December 2018.
http://dot.state.mn.us/research/TRS/2018/TRS1808.pdf
Although this Transportation Research Synthesis focuses on effective methods and practices of involving individuals with visual impairment in planning and designing transportation facilities, the report includes resources about assistive technologies for persons with visual impairment as well as designing transportation facilities for persons with visual impairment. *From the executive summary*:

> The MnDOT Office of Transportation System Management is exploring best practices for assessing the transportation-related needs of the community of persons with visual impairment and for involving members of this community in decisions related to fulfilling those needs in MnDOT projects. Of particular interest are lessons learned by other state departments of transportation, metropolitan planning organizations and regional development commissions that have conducted substantial work in this area to understand how they assess the transportation priorities of people with visual impairment related to pedestrian travel, transit and light rail, and how they involve individuals with visual impairment in decision-making about transportation facility features and plans.

Texas

"Capital Metro Tests App to Provide Real-Time Info to Blind Riders," TheTransitWire.com, March 14, 2018.
http://www.thetransitwire.com/2018/03/14/capital-metro-tests-app-to-provide-real-time-info-to-blind-riders/
From the online article: Capital Metro (TX) [Austin, Texas, public transit system] is testing a program to provide real-time bus information and service alerts to riders who are blind or visually impaired.

Bus riders using the BlindSquare mobile app will receive real-time bus schedule and service alert information automatically when they are in proximity to the stop. A network of beacons delivers the information to the app.
….
The pilot program will run for 60 days at 16 Capital Metro bus stops in downtown Austin and will initially be available to selected beta testers.

Related Resource:

> **"What is BlindSquare?"** BlindSquare.com, undated.
> https://www.blindsquare.com/about/
> *From the web site*: BlindSquare is the world's most widely used accessible GPS-app developed for the blind and visually impaired. Paired with third-party navigation apps, BlindSquare's self-voicing app delivers detailed points of interest and intersections for safe, reliable travel both outside and inside.

Washington

"Where's My Bus Stop? Supporting Independence of Blind Transit Riders With StopInfo," Megan Campbell, Cynthia Bennett, Caitlin Bonnar and Alan Borning, *Proceedings of the 16th International ACM SIGACCESS Conference on Computers and Accessibility*, pages 11-18, October 2014.
https://dl.acm.org/doi/pdf/10.1145/2661334.2661378?download=true
From the abstract: Locating bus stops, particularly in unfamiliar areas, can present challenges to people who are blind or low vision. At the same time, new information technology such as smartphones and mobile devices [has] enabled them to undertake a much greater range of activities with increased independence. We focus on the intersection of these issues. We developed and deployed StopInfo, a system for public transit riders that provides very detailed information about bus stops with the goal of helping riders find and verify bus stop locations. We augmented internal information from a major transit agency in the Seattle area with information entered by the community, primarily as they waited at these stops. Additionally, we conducted a five week field study with six blind and low vision participants to gauge usage patterns and determine values related to independent travel. We found that StopInfo was received positively and is generally usable. Furthermore, the system supports tenets of independence; participants took public transit trips that they might not have attempted otherwise. Lastly, an audit of bus stops in three Seattle neighborhoods found that information from both the transit agency and the community was accurate.

Related Resource:

"Announcing StopInfo!" OneBusAway Blog, February 20, 2014.
http://onebusaway.blogspot.com/2014/02/announcing-stopinfo.html
From the blog post: We are excited to announce the launch of StopInfo! StopInfo is a new service linked with OneBusAway for the Puget Sound region that provides detailed information about bus stops. Our initial focus is on increasing the accessibility of bus stops for people who are blind or visually impaired. Knowing information ahead of time about a bus stop, such as which side of the intersection it is on and what type of bus sign it has, can reduce the time and hassle it takes to find the bus stop. This information also includes landmarks surrounding the bus stop, such as shelters and trash cans. We are excited to partner with the community to not only increase access for people who are blind or visually impaired, but for anyone who may be looking for an unfamiliar bus stop.

Wisconsin

"Milwaukee County Launches Pilot Program to Expand Accessibility for MCTS Riders," *Mass Transit,* February 5, 2020.
https://www.masstransitmag.com/technology/passenger-info/mobile-applications/press-release/21124323/milwaukee-county-transit-system-mcts-milwaukee-county-launches-pilot-program-to-expand-accessibility-for-mcts-riders
From the online article: The launch of a pilot program that supports Milwaukee County Transit System (MCTS) riders who are blind or low vision with increased access to public transportation has been announced by Milwaukee County Executive Chris Abele, MCTS and the Milwaukee County Office for Persons with Disabilities (OPD).

Through Aira, an app available on any iOS or Android smartphone, users can receive free, one-on-one assistance riding the bus and navigating the more than 5,000 bus stops in Milwaukee County.

Related Resources:

"The World Can Be Complex. Using Aira is Simple," Aira Tech Corporation, 2017-2018.
https://aira.io/how-it-works
From the web site: Aira is a service that connects blind and low-vision people to highly trained, remotely-located agents. Through an app on your smartphone, Aira delivers instant access to visual information at the touch of a button—enhancing everyday efficiency, engagement and independence. Straightforward and simple.

"MBTA Launches AccessAI Pilot Connecting Blind and Low Vision Users With Aira's Human Artificial Intelligence Technology," Announcement/Press Release, Aira Tech Corporation, May 3, 2019.
https://aira.io/mbta-launches-accessai
From the announcement: The MBTA [Massachusetts Bay Transportation Authority] announced the launch of a free six-month accessibility technology pilot called "AccessAI" featuring Aira's human artificial intelligence (human AI) technology at a kick-off event and live demonstration held today at Government Center Station.
….
Aira connects blind or low vision users with highly trained sighted agents who provide visual information about the user's surrounding environment—live and on-demand through smartphone video technology. During the six-month pilot that began on May 1, the Aira

smartphone app, powered by AT&T, will be free to users throughout the MBTA system at all bus stops, subway stations, [c]ommuter [r]ail stations and ferry routes.

"MTA NYC to Offer Free Access to Aira," Announcement/Press Release, Aira Tech Corporation, October 16, 2019.
https://aira.io/mta
From the announcement: The NY MTA [New York Metropolitan Transportation Authority] launched a three-month pilot today for Aira services at an opening ceremony held at the Jay Street-MetroTech accessibility model station. Aira can now be used for free at all 496 subway stations, as well as a phased rollout of free Aira Access for all 13K bus routes.

How [I]t Works: Aira, powered by AT&T, combines mobile technology, artificial intelligence and real-time human interaction to provide visual information to people who are blind or have low vision. Using a smartphone—or a pair of Aira's proprietary Horizon Smart Glasses—an Aira user connects to a remote professional agent, who can see the user's surroundings through their device's camera. This, coupled with the AI-powered Remote Presence Dashboard, enables agents to provide real-time audio descriptions as well as GPS location, maps, rideshare and photo-sharing capabilities, and more.

In locations where Aira Access is enabled, users can connect to Aira free of charge. MTA travelers new to Aira can download the free app from the Apple [a]pp and Google Play stores. With just the touch of a button, anyone using the Aira app can connect with an agent to navigate the MTA system at all subway stations and bus routes.

Smartphone and Other Applications

GPS and Wayfinding Apps, The National Library Service for the Blind and Print Disabled, February 2020.
https://www.loc.gov/nls/resources/general-resources-on-disabilities/gps-and-wayfinding-apps/
From the introduction: People with visual disabilities use a variety of tools to help them navigate their environment. Non-technological methods include white canes and service animals. This reference guide offers an overview of the technological solutions for people with disabilities when in transit from one location to another. Listed in this resource are mobile applications (apps) for mobile devices that can aid people with visual impairments in finding destinations. The apps listed below are for use in conjunction with white canes and service animals, not to replace them. Prices are subject to change and listing in this reference guide does not constitute endorsement.

"Mobility Technologies for Blind, Partially Sighted and Deafblind People: Design Issues," M.A. Hersh, *Mobility of Visually Impaired People*, pages 377-409, 2017.
Chapter description at https://link.springer.com/chapter/10.1007/978-3-319-54446-5_13
From the abstract: The chapter provides an overview of the factors to be considered in the design of travel aids which meet the needs of blind, visually impaired and deafblind people. The chapter consists of two main parts. The first part comprises an introduction, brief discussions of the long cane as a successful travel aid (with limitations) and how blind people travel; a categorization of travel aids and an overview of the three main phases of travel aid development. The second part considers the specifics of good design practice. The topics covered include specific principles of good design practice, app design, end-user involvement and particular features, including functionality, the interface, sensors, privacy and context awareness.

"Feasibility of Using Haptic Directions Through Maps With a Tablet and Smart Watch for People Who are Blind and Visually Impaired," William Grussenmeyer, Jesel Garcia and Fang Jiang, *Proceedings of the 18th International Conference on Human-Computer Interaction With Mobile Devices and Services*, pages 83-89, September 2016.
https://dl.acm.org/doi/pdf/10.1145/2935334.2935367
From the abstract: In order to navigate through the world, people who are blind and visually impaired typically use maps through either textual directions or tactile printouts. However, visual maps on a touchscreen are not accessible to this population. Two prototypes were designed to test users' ability to trace graphical lines and directions through maps on a touchscreen using haptic feedback from an Android smart watch and tablet. With the first prototype, we show that blind and visually impaired users had lower threshold than sighted users for determining the distance between two lines on a touchscreen, suggesting their enhanced ability to form representations of spatial distance from tactile vibrational cues. With the second prototype, we show that it is feasible for blind and visually impaired users to follow directions through graphical maps based on vibrational cues. We believe these results show that our prototypes have the potential to be effective in real-world applications.

"Incorporating Information From Trusted Sources to Enhance Urban Navigation for Blind Travelers," Byung-Cheol Min, Surynash Saxena, Aaron Steinfeld and M. Bernadine Dias, *2015 IEEE International Conference on Robotics and Automation*, May 2015.
Citation at https://ieeexplore.ieee.org/abstract/document/7139824
From the abstract: Dynamic changes can present significant challenges for visually impaired travelers to safely and independently navigate urban environments. To address these challenges, we are developing the NavPal suite of technology tools. NavPal includes a dynamic guidance tool in the form of a smartphone app that can provide real-time instructions based on available map information to guide navigation in indoor environments. In this paper we enhance our past work by introducing a framework for blind travelers to add map/navigation information to the tool, and to invite trusted sources to do the same. The user input is realized through audio breadcrumb annotations that could be useful for future trips. The trusted sources mechanism provides invited trusted individuals or organizations an interface to contribute real-time information about the surrounding environment. We demonstrate the feasibility of our solution through a prototype Android smartphone-based outdoor navigation aid for blind travelers. An initial usability study with visually impaired adults informed the design and implementation of this prototype.

Enhancing the Safety of Visually Impaired Travelers In and Around Transit Stations, Alekhya Jonnalalgedda, Lucy Pei, Suryansh Saxena, Ming Wu, Byung-Cheol Min, Ermine A. Teves, Aaron Steinfeld and M. Bernadine Dias, U.S. Department of Transportation and The Robotics Institute, Carnegie Mellon University, December 2014.
https://www.ri.cmu.edu/pub_files/2014/12/NavPalTechReport2014Final.pdf
From the abstract: We have been exploring specific needs and constraints encountered by this user population when using transit stations. Based on our findings, we created a set of design guidelines for useful technology targeting this user population and prototyped an accessible smartphone tool that has significant potential to enhance the safety of these travelers. This tool allows travelers to annotate their paths and choose/invite trusted sources to enhance the relevant information that can enhance the safety and efficacy of their travel.

"Enhancing Independence and Safety for Blind and Deaf-Blind Public Transit Riders," Shiri Azenkot, Sanjana Prasain, Alan Borning, Emily Fortuna, Richard E. Ladner and Jacob O. Wobbrock, *Proceedings of the SIGCHI [Special Interest Group on Computer-Human Interaction] Conference on Human Factors in Computing Systems*, pages 3247-3256, May 2011.
https://faculty.washington.edu/wobbrock/pubs/chi-11.04.pdf
From the abstract: We conducted semi-structured interviews with 13 blind and deaf-blind people to understand how they use public transit and what human values were important to them in this domain. Two key values were identified: independence and safety. We developed GoBraille, two related Braille-based applications that provide information about buses and bus stops while supporting the key values. GoBraille is built on MoBraille, a novel framework that enables a Braille display to benefit from many features in a smartphone without knowledge of proprietary, device-specific protocols. Finally, we conducted user studies with blind people to demonstrate that GoBraille enables people to travel more independently and safely.

Indoor Navigation

"Indoor Navigation by People With Visual Impairment Using a Digital Sign System," Gordon E. Legge, Paul J. Beckmann, Bosco S. Tjan, Gary Havey, Kevin Kramer, David Rolkosky, Rachel Gage, Muzi Chen, Sravan Puchakayala and Aravindhan Rangarajan, *PLOS ONE*, October 2013.
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0076783
From the abstract: There is a need for adaptive technology to enhance indoor wayfinding by visually-impaired people. To address this need, we have developed and tested a Digital Sign System. The hardware and software consist of digitally-encoded signs widely distributed throughout a building, a handheld sign-reader based on an infrared camera, image-processing software, and a talking digital map running on a mobile device. Four groups of subjects—blind, low vision, blindfolded sighted, and normally sighted controls—were evaluated on three navigation tasks. The results demonstrate that the technology can be used reliably in retrieving information from the signs during active mobility, in finding nearby points of interest, and following routes in a building from a starting location to a destination. The visually impaired subjects accurately and independently completed the navigation tasks, but took substantially longer than normally sighted controls. This fully functional prototype system demonstrates the feasibility of technology enabling independent indoor navigation by people with visual impairment.

"PERCEPT Indoor Navigation System for the Blind and Visually Impaired: Architecture and Experimentation," Aura Ganz, James Schafer, Siddhesh Gandhi, Elaine Puleo, Carole Wilson and Meg Robertson, *International Journal of Telemedicine and Applications*, Vol. 2012, December 2012.
https://doi.org/10.1155/2012/894869
From the introduction: In this paper we introduce PERCEPT system that provides enhanced perception of the indoor environment using passive radio frequency identification (RFID) tags deployed in the environment, a custom-designed handheld unit and [s]martphone carried by the user, and PERCEPT server that generates and stores the building information and the RFID tags deployment. When a user, equipped with PERCEPT glove and a [s]martphone, enters a multistory building equipped with PERCEPT system, he/she scans the destination at the kiosk located at the building entrance. The PERCEPT system directs the user to his/her chosen destination using landmarks (e.g., rooms, elevator, etc.). PERCEPT is different from other systems in the following aspects: (1) the user carries a custom made handheld unit with small form factor and an Android-based phone, (2) the system builds upon O&M [orientation and mobility] principles, and (3) it is the first indoor navigation system tested with 24 blind and

visually impaired subjects (other systems were either tested with up to three visually impaired users or were tested with blindfolded sighted users).

"The User as a Sensor: Navigating Users With Visual Impairments in Indoor Spaces Using Tactile Landmarks," Navid Fallah, Ilias Apostolopoulos, Kostas Bekris and Eelke Folmer, *Proceedings of the SIGCHI [Special Interest Group on Computer-Human Interaction] Conference on Human Factors in Computing Systems*, pages 425-432, May 2012.
https://dl.acm.org/doi/pdf/10.1145/2207676.2207735
From the abstract: Indoor navigation systems for users who are visually impaired typically rely upon expensive physical augmentation of the environment or expensive sensing equipment; consequently few systems have been implemented. We present an indoor navigation system called Navatar that allows for localization and navigation by exploiting the physical characteristics of indoor environments, taking advantage of the unique sensing abilities of users with visual impairments, and minimalistic sensing achievable with low cost accelerometers available in smartphones. Particle filters are used to estimate the user's location based on the accelerometer data as well as the user confirming the presence of anticipated tactile landmarks along the provided path. Navatar has a high possibility of large-scale deployment, as it only requires an annotated virtual representation of an indoor environment. A user study with six blind users determines the accuracy of the approach, collects qualitative experiences and identifies areas for improvement.

Indoor/Outdoor Navigation

Project in Progress: Seamless Wayfinding by Individuals With Functional Disability in Indoor and Outdoor Spaces: An Investigation Into Lived Experiences, Data Needs and Technology Requirements, University Transportation Centers Program, start date: August 2019; expected completion date: December 2020.
Project description at https://trid.trb.org/view/1636281
From the project description: This collaborative project will employ a mixed-method design to develop a saliency feature inventory for supporting effective wayfinding design for individuals with visual impairments, blindness and deafblindness in urban environments. Drawing from the academic literature, the technical expertise of the American Printing House for the Blind, and engaging individuals with visual impairments ages 14 and older in focus groups, interviews and structured travel observations, the research team will distill elements of personal and environmental affordances that support effective wayfinding experiences. The elements of environmental saliency will be discovered using both qualitative and quantitative methods, including survey instruments, interviews, participant observations, structured data assessments, digital mapping, and spatial data collection and analysis. Using Portland State University as the pilot study site, the team will evaluate the validity and efficacy of the saliency feature inventory and wayfinding technology selection with constituents and expert advisors, sharing outcomes and insights iteratively with interdisciplinary networks. This project promises to drive forward the development of standards and innovation in mobile wayfinding as it relates to the integration of indoor and outdoor wayfinding and routing of visually-impaired, blind and deafblind pedestrian travelers. Further it provides planners, designers, educators, researchers, practitioners and community members a working inclusive model to evaluate and scale on campus and communities.

Technological Trends in Improved Mobility of the Visually Impaired, Sara Paiva, ed., 2020.
Book description at https://www.springer.com/gp/book/9783030164492#aboutBook
From the book description: The book's topics include, but are not limited to, obstacle detection systems, indoor and outdoor navigation, transportation sustainability systems and hardware/devices to aid visually impaired people. The book has a strong focus on practical

applications, tested in a real environment. Applications include city halls, municipalities and companies that can keep up to date with recent trends in platforms, methodologies and technologies to promote urban mobility. Also discussed are broader realms including education, health, electronics, tourism and transportation. Contributors include a variety of researchers and practitioners around the world.

- Features practical, tested applications of technological mobility solutions for visual[ly] impaired people;
- Presents topics such as obstacle detection systems, urban mobility, smart home services and ambient assisted living;
- Includes a number of application examples in education, health, electronics, tourism and transportation.

"Comparing Tactile to Auditory Guidance for Blind Individuals," Arnav Bharadwaj, Saurabh Bhaskar Shaw and Daniel Goldreich, *Frontiers in Human Neuroscience*, Vol. 13, December 2019.
https://doi.org/10.3389/fnhum.2019.00443
From the abstract: Here, we explored the efficacy of a tactile navigational aid that provides turn signals via vibrations on a hip-worn belt. We compared the performance of 12 blind participants as they navigated a series of paths under the direction of the tactile belt or conventional auditory turn commands; furthermore, we assessed the effect of repeated testing, both in the presence and absence of simulated street sounds. A computer-controlled system triggered each turn command, measured participants' time-to-path-completion and detected major navigational errors. When participants navigated in a silent environment, they performed somewhat worse with the tactile belt than the auditory device, taking longer to complete each trial and committing more errors. When participants navigated in the presence of simulated street noises, the difference in completion time between auditory and tactile navigation diminished. These results suggest that tactile navigation holds promise as an effective method in everyday environments characterized by ambient noise such as street sounds.

"Building Smart Transportation Hubs With 3D Vision and Video Technologies to Improve Services to People With Disabilities," Jie Gong, Cecilia Feeley, Hao Tang, Greg Olmschenk, Vishnu Nair, Zixiang Zhou, Yi Yu, Ken Yamamoto and Zhigang Zhu, *TRB 96th Annual Meeting Compendium of Papers*, Paper #17-02576, 2017.
Citation at https://trid.trb.org/view/1438080
From the abstract: The primary objective of this research is to design and develop a novel cyber-physical infrastructure that can effectively and efficiently transform existing transportation hubs into smart facilities capable of providing better location-aware services (e.g., finding terminals, improving travel experience, obtaining security alerts). The authors investigated the integration of a number of novel internet of things elements, including video analytics, low-cost Bluetooth beacons, mobile computing and LiDAR-scanned 3D semantic models, to provide reliable indoor navigation services to people with traveling challenges, yet requiring minimum infrastructure changes since the authors' approach leverages existing cyberinfrastructures such as surveillance cameras, facility models and mobile phones, and incorporates a minimum number of new and small devices such as beacons to achieve reliable navigation services. The authors choose two groups of people for the authors' initial study—those with visual impairment and ASD [autism spectrum disorder] since both groups face difficulties in a crowded and complex 3D environment. Thus two unique features of the authors' solution are the use of 3D digital semantic models and crowd analysis with surveillance cameras for providing the best available paths. The authors have started a pilot test with people with disabilities at a multi-floor building in New York City to demonstrate the effectiveness of the proposed framework.

"Navigating With a Visual Impairment: Problems, Tools and Possible Solutions," Michael Schwartz and Denise Benkert, *10th International Conference on Foundations of Augmented Cognition: Neuroergonomics and Operational Neuroscience,* Vol. 9744, pages 371-381, July 2016.
https://doi.org/10.1007/978-3-319-39952-2_36
From the abstract: In this paper we discuss various navigational aids for people who have a visual impairment. Navigational technologies are classified according to the mode of accommodation and the type of sensor utilized to collect environmental information. Notable examples of navigational aids are discussed, along with the advantages and disadvantages of each. Operational and design considerations for navigational aids are suggested. We conclude with a discussion of how multimodal interaction benefits people who use technology as an accommodation and can benefit everyone.

"Improving Public Transit Accessibility for Blind Riders by Crowdsourcing Bus Stop Landmark Locations With Google Street View: An Extended Analysis," Kotaro Hara, Shiri Azenkot, Megan Campbell, Cynthia L. Bennett, Vicki Le, Sean Pannella, Robert Moore, Kelly Minckler, Rochelle H. Ng and Jon Froehlich, *ACM Transactions on Accessible Computing*, Vol. 6, Issue 2, March 2015.
https://dl.acm.org/doi/pdf/10.1145/2717513
From the abstract: In this article, we introduce and evaluate a new scalable method for collecting bus stop location and landmark descriptions by combining online crowdsourcing and Google Street View (GSV). We conduct and report on three studies: (i) a formative interview study of 18 people with visual impairments to inform the design of our crowdsourcing tool, (ii) a comparative study examining differences between physical bus stop audit data and audits conducted virtually with GSV, and (iii) an online study of 153 crowd workers on Amazon Mechanical Turk to examine the feasibility of crowdsourcing bus stop audits using our custom tool with GSV. Our findings reemphasize the importance of landmarks in nonvisual navigation, demonstrate that GSV is a viable bus stop audit data set, and show that minimally trained crowd workers can find and identify bus stop landmarks with 82.5% accuracy across 150 bus stop locations (87.3% with simple quality control).

Improving Transit Facility Accessibility by Employing Wayfinding Technology, Information Brief, National Aging and Disability Transportation Center, November 2011.
https://www.nadtc.org/wp-content/uploads/Wayfinding-Technology.pdf
From the introduction: This information brief focuses on identifying new technologies that improve accessibility within transit systems, especially for customers who are blind or have visual impairments and use wayfinding to navigate their environment. Wayfinding is the process of applying orientation strategies and mobility skills to negotiate an environment and locate an intended destination.

Wayfinding systems allow people to "(1) determine their location within a setting, (2) determine their destination and (3) develop a plan that will take them from their location to their destination."

WeWALK Smart Cane, WeWalk, undated.
https://wewalk.io/en/
From the web site:

> **Detect Obstacles**
> WeWALK detects obstacles at head level with an ultrasonic sensor and warns you with vibration. Also, you can adjust the obstacle detection distance between 80 cm and 170 cm.

Get Blind Friendly Navigation
WeWALK Smart Cane has free mobile applications for iOS and Android. You can save your favorite places and get turn-by-turn and clockwise navigation through the cane while your phone is in your pocket.

Search for Nearby Places and Explore the Area
WeWALK helps you to find popular places, restaurants, pubs and cafes around you. All you need to do is to choose where to go and get navigation over your WeWALK application.

Enhancing Transit Facilities

Impacts of Bus Stop Improvements, Ja Young Kim, Keith Bartholomew and Reid Ewing, Utah Department of Transportation, March 2018.
https://www.udot.utah.gov/main/uconowner.gf?n=42420111425367128
From the abstract: This study analyzes recent bus stop improvements made by the Utah Transit Authority (UTA) to determine whether, and to what extent, the improvements are associated with changes in stop-level ridership and demand for Americans with Disabilities Act (ADA) paratransit service in the areas immediately surrounding improved bus stops. The study compares ridership and paratransit demand from before and after the improvements at the treated stops and at a set of unimproved stops selected using propensity score matching to control for demographic, land use and regional accessibility influences. The analysis shows that the improved bus stops are associated with a statistically significant increase in overall ridership and a decrease in paratransit demand, compared to the control group stops. These outcomes are important for transit service providers as they seek to increase overall ridership and reduce costs associated with providing paratransit service.

"Access to Urban Transportation System for Individuals With Disabilities," N. N. Sze and Keith Christensen, *IATSS Research*, Vol. 41, Issue 2, pages 66-73, July 2017.
https://www.sciencedirect.com/science/article/pii/S0386111217300444
From the abstract: This study attempts to review the current practices and guidelines for accessible design of transportation, both access to and within transport facilities, based on the information from the United States, United Kingdom and Hong Kong. Besides, the effects of accessible design of transportation on perceived level of service, accessibility, safety and travel behavior would be examined. Therefore, good practices of accessible design that could address the needs for all, especially the elderly and individuals with different types of disability including visual impairment, hearing difficulty and reduced mobility, could be recommended. Hence, [the] quality of life of [a] vulnerable group can be enhanced, and community integration will be achieved in the long run.

Survey of Practice

An online survey attempted to gather information from selected transit-related contacts inside and outside California about the assistive technologies currently employed to enhance transit services for travelers with disabilities. The survey also sought information about future plans to adopt assistive technology, user assessment of current transit services, and special training that agencies provide for transit service staff members to prepare them for communicating with travelers with disabilities.

The survey was distributed to California's 18 metropolitan planning organizations (MPOs) and 10 MPOs serving large urban areas outside California. Survey respondents also included three people representing advocacy organizations for disabled populations in California:

- California Deaf Education Resource Center.
- California State Council on Developmental Disabilities.
- Inland Empire Lighthouse for the Blind.

Survey questions are provided in Appendix A. The full text of survey responses is presented in a supplement to this report.

Summary of Survey Results

The survey received an extremely limited response, with just three California transit agencies and one advocacy group responding:

California Transit Agencies

- City of Roseville/Roseville Transit.
- Modesto Area Express.
- Transit Joint Powers Authority for Merced County.

Advocacy Groups

- California State Council on Developmental Disabilities.

Of these, only the Modesto Area Express respondent provided information about the current use of assistive technologies to enhance transit services for travelers with disabilities.

Assistive Technologies for Disabled Travelers: Modesto Area Express

Modesto Area Express is currently employing three assistive technologies to aid disabled travelers:

- Accessible vehicles (including assistive listening systems and redundant visual/auditory service announcements).
- Provision of real-time arrival information.
- Wi-Fi access points at transit stops and buses that communicate with travelers' smartphones or tablets.

The respondent noted that real-time arrival information has been most effective for all travelers, not just those with disabilities. Wi-Fi access points are deemed the least effective, with the respondent noting that "many people have a cellular connection." The respondent's

recommendation for other transit agencies wishing to better serve disabled populations: Provide real-time information for both fixed-route and paratransit services, and make sure the transit provider's app or web site is accessible.

Plans to Enhance Transit Services for Travelers With Disabilities

Three respondents described expectations or plans for enhancing transit services for travelers with disabilities:

- The California State Council on Developmental Disabilities member expects online ride reservations to be offered in the future. (Modesto Area Express and Roseville Transit are moving toward offering this service; see below.)
- Modesto Area Express respondent reported that the agency plans to provide more technology options for its paratransit operation, including an app that will track the vehicle, allow trip requests, pay for the trip, review upcoming and past trips, and provide alerts.
- The Roseville Transit respondent noted that transit operators within the South Placer County region recently included mobile data tablets on all demand response vehicles. (This includes Placer County Transit, Roseville Transit and Health Express vehicles used for intercity nonemergency medical trips.) Addition of these devices will enable Roseville Transit to soon implement automated notifications a day in advance and minutes prior to bus arrival. Roseville Transit is also moving toward allowing passengers within the South Placer County region to request trip reservations and self-manage their trips online.

Special Training for Transit Service Staff Members

Two of the three transit agency respondents reported on mandatory training programs that include sensitivity training to help prepare transit service staff members for communicating with travelers with disabilities. The third transit agency respondent commented on the significance of this type of training. The following summarizes survey responses:

- Modesto Area Express staff members are required to have sensitivity training.
- Mandatory driver training for Roseville Transit staff members includes sensitivity training. Refresher training in alternative modes of providing information is scheduled periodically for all staff members.
- The Transit Joint Powers Authority for Merced County respondent noted that "[h]ands-on training is helpful so that those who cannot relate to disabilities can understand why it is important to provide service [that meets] their needs."

Contacts

CTC contacted the individuals below to gather information for this investigation.

California Transit Agencies

City of Roseville/Roseville Transit

Eileen Bruggeman
Alternative Transportation Manager
916-774-5449, ebruggeman@roseville.ca.us

Modesto Area Express

Adam Barth
Transit Manager
209-577-5298, abarth@modestogov.com

Transit Joint Powers Authority for Merced County

Malee Unruh
Grant Analyst
209-723-3100, malee.unruh@mercedthebus.com

California Advocacy Groups

California State Council on Developmental Disabilities

Lisa Cooley
Governor's Appointee
916-607-4996, lisamariecooley@aol.com

Appendix A: Survey Questions

The following survey was distributed to transit-related contacts at California's 18 metropolitan planning organizations (MPOs) and 10 MPOs serving large urban areas outside California. Survey respondents also included three people representing advocacy organizations for disabled populations in California.

Note: The response to the question below determines how a respondent is directed through the survey.

In addition to the question sets identified in the first required question below, all respondents were presented with questions in **Agency Outreach to Travelers With Disabilities** and **Wrap-Up**.

(Required) Has your agency, or a transit agency within your service area, adopted innovative technology to enhance services to travelers with disabilities? Select the best response below.

- Yes, our agency has adopted innovative technology for this purpose. (skips respondent to **In-House Application of Innovative Technology**)
- No, but we're aware of another agency in our service area that has adopted technology for this purpose. (skips respondent to **Other Agency Application of Innovative Technology**)
- No, but we're planning to enhance transit services for travelers with disabilities. (skips respondent to **Agencies Planning to Enhance Transit Services**)
- No, and we're not actively seeking to apply new technologies. (skips respondent to **Agency Outreach to Travelers With Disabilities**)

Agencies Planning to Enhance Transit Services

Please describe your agency's plans to enhance transit services for travelers with disabilities.

In-House Application of Innovative Technology

1. Please identify the innovative technology your agency has adopted to enhance transit services for travelers with disabilities. Select all that apply.
    - Accessible stations/stops (including assistive listening systems and redundant visual/auditory service announcements)
    - Accessible vehicles (assistive listening systems and redundant visual/auditory service announcements)
    - Connective communication technologies (vehicle-to-vehicle, vehicle-to-infrastructure and vehicle-to-pedestrian)
    - Development of custom apps or web applications that provide location-based services to users or alert relevant authorities when assistance is needed
    - Devices or terminals installed in vehicles to provide concierge services
    - Indoor mobility services that assist with obstacle avoidance, orientation, navigation and travel
    - Outdoor mobility services that assist with obstacle avoidance, orientation, navigation and travel
    - Provision of location-centric transit information
    - Provision of real-time arrival information

- Sensor or surveillance readings (vehicle fullness)
- Video relay service to assist the deaf and hard of hearing
- Wi-Fi access points at transit stops and buses that communicate with customers' smartphones or tablets
- Other (please describe)

2. Which technologies have you found to be **most effective** in enhancing transit services for travelers with disabilities?
3. Which technologies have you found to be **least effective** in enhancing transit services for travelers with disabilities?
4. What are your agency's top three recommendations to another agency wishing to use technology to enhance transit services for travelers with disabilities?

Other Agency Application of Innovative Technology

1. Please identify the innovative technology another agency in your service area has adopted to enhance transit services for travelers with disabilities. Select all that apply.
    - Accessible stations/stops (including assistive listening systems and redundant visual/auditory service announcements)
    - Accessible vehicles (assistive listening systems and redundant visual/auditory service announcements)
    - Connective communication technologies (vehicle-to-vehicle, vehicle-to-infrastructure and vehicle-to-pedestrian)
    - Development of custom apps or web applications that provide location-based services to user or alert relevant authorities when assistance is needed
    - Devices or terminals installed in vehicles to provide concierge services
    - Indoor mobility services that assist with obstacle avoidance, orientation, navigation and travel
    - Outdoor mobility services that assist with obstacle avoidance, orientation, navigation and travel
    - Provision of location-centric transit information
    - Provision of real-time arrival information
    - Sensor or surveillance readings (vehicle fullness)
    - Video relay service to assist the deaf and hard of hearing
    - Wi-Fi access points at transit stops and buses that communicate with customers' smartphones or tablets
    - Other (please describe)
2. Please provide the name of the transit agency adopting this technology. If you can, please also provide contact information.

Agency Outreach to Travelers With Disabilities

1. Has your agency conducted a survey of travelers with disabilities to gauge user needs and satisfaction with current transit services?
    - No
    - Yes (Please provide information about the survey or survey findings, if available. Send any files not available online to carol.rolland@ctcandassociates.com.)

2. Does your agency have a plan to further enhance transit services for travelers with disabilities?
    - No
    - Yes (please describe your agency's plan)
3. Does your agency recommend or support special training for transit service staff to prepare them for communicating with travelers with disabilities?
    - No
    - Yes (please describe the training program)

Wrap-Up

Please use this space to provide any comments or additional information about your previous responses.