

Accessible Transportation Technologies Research Initiative (ATTRI)

User Needs Assessment: Stakeholder Engagement Report

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ACCESSIBLE TRANSPORTATION TECHNOLOGIES
RESEARCH INITIATIVE



U.S. Department of Transportation

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16. Abstract The Accessible Transportation Technologies Research Initiative (ATTRI) is a joint U.S. Department of Transportation (U.S. DOT) initiative that is co-led by the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA). ATTRI is also supported by the Intelligent Transportation Systems (ITS) Joint Program Office (JPO), National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR), and other Federal agencies. The execution of ATTRI is being conducted in three (3) phases spanning over six (6) years: Exploratory and User Needs Research Phase (Year 1), Innovation and Prototype Phase (Years 2-4), and Demonstration Phase (Years 5-6). Within each Phase, a number of activities are being conducted including extensive stakeholder outreach, communications, and technology scanning activities to identify the current state of the industry. This document provides a report on one such activity that was conducted to solicit feedback and information from stakeholders on user needs for ATTRI's user groups. Three different stakeholder engagement and outreach activities were conducted as part of this project including a literature review, a series of three webinars, presentation at several conferences with "listening sessions," and one in-person workshop.					
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Executive Summary

The Accessible Transportation Technologies Research Initiative (ATTRI) is a joint U.S. Department of Transportation (U.S. DOT) initiative that is co-led by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA). ATTRI is also supported by the Intelligent Transportation Systems (ITS) Joint Program Office (JPO), National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR), and other Federal agencies. ATTRI's mission statement defines the Initiative's purpose, the people it serves, and its primary objectives:¹

The mission of ATTRI is to transform the mobility of travelers with disabilities by providing the capability to reliably, safely and independently plan and execute their travel. ATTRI identifies, coordinates, develops, and implements new integrated solutions in advancing accessible transportation and universal mobility.

The execution of ATTRI is being conducted in three (3) phases spanning over six (6) years: Exploratory and User Needs Research Phase (Year 1), Innovation and Prototype Phase (Years 2-4), and Demonstration Phase (Years 5-6). Within each Phase, a number of activities are being conducted, including extensive stakeholder outreach, communications, and scanning activities to solicit feedback and information from stakeholders on user needs for ATTRI's user groups.

This document provides a report on one such activity focused on soliciting feedback and information from stakeholders on user needs and barriers to mobility. Several different stakeholder engagement and outreach activities were conducted as part of this project including a literature review, a series of webinars, presentations at several conferences with "listening sessions," and an in-person workshop. Each of these efforts was designed to provide information on many of the same topics – though using different mediums and techniques. Results from each activity were used as initial inputs for the remaining activities, allowing for the development of common themes and gathering of detailed information from stakeholders. The literature review, which was conducted first, provided insights into the historical perspectives of stakeholders as reported on by other researchers. This information directly informed the development of discussion topics and focus areas for a series of webinars. In turn, the webinars provided the second layer of context and information that was utilized and explored as part of an in-person workshop.

Access to transportation is an extremely important policy issue for people with mobility needs. People with disabilities, Veterans with disabilities, and older adults have the same travel expectations as individuals with unrestricted mobility. The literature review provides a perspective into the characteristics of those sub-segments of the populations that are of interest to ATTRI. As identified and reported in the literature review, the definition of what constitutes a disability is not uniform. The Americans with Disabilities Act (ADA, 1990) defines a person with a disability as a person who has a physical or cognitive impairment that substantially limits one or more major life activities. Within this broad definition, there are many aspects and types of disabilities, but they generally fall within one of four overall categories defined by visual, hearing, cognitive, and mobility disabilities. Regardless of the sub-segment of the population, many of the fundamental user needs for these groups of persons were found to be very similar across the literature review, webinars, and workshop. The participant

¹ U.S. DOT Accessible Transportation Technology Research Initiative 2014-2019 Strategic Plan, 2014.

responses from the webinars and workshop, coupled with the literature review, clearly demonstrate that people with disabilities, Veterans with disabilities, and older adults face significant transportation challenges and have many different types of needs and barriers to their travel. However, participants in the workshop identified many potential technologies that may be capable of meeting these needs and overcoming barriers. In particular, within each of the five technology focus areas are defined by U.S. DOT as: (1) Wayfinding and Navigational Solutions, (2) Assistive Technologies, (3) Automation and Robotics, (4) Data Integration, and (5) Enhanced Human Services Transportation. Specific types of technology needs were identified as potentially providing avenues for technology insertion to address a significant portion of the needs and barriers of persons with disabilities.

Observations from in-person “listening sessions” at several conferences and an in-person workshop, as reflected in the responses and feedback gathered from participants, confirmed that each of the five technology focus areas have the potential to address needs and overcome barriers to travel across all four types of disabilities. However, the user needs and technology solutions identified through the activities of this project were not uniform and are thus unable to singularly address all needs and barriers. Table ES-1 provides a crosswalk of the types of user needs and barriers with each of the five technology focus areas and identifies an assessed level of potential for addressing the need or overcoming the barrier based upon the information provided by both workshop and webinar participants. Technology focus areas that were assessed as “Strong” were those where a direct connection and linkage between the user need/barrier were identified across multiple sources of information. Technology focus areas that were assessed as “Some” were those areas where the technologies were not *consistently* or *uniformly* identified as a potential solution for addressing the user need or barrier. Technology focus areas that were assessed as “Limited” either generally were not identified as potential solutions, or were identified only by a very small number of sources in this project.

Table ES-1. Crosswalk of User Needs/Barriers with Technology Focus Areas

User Needs/Barriers	Type of Need/Barrier	Wayfinding and Navigation	Assistive Technologies	Automation and Robotics	Data Integration	Enhanced Human Services Transportation
User Needs	Information	Strong	Strong	Some	Some	Strong
	Options	Limited	Some	Strong	Limited	Strong
	Assistance	Limited	Some	Some	Some	Some
	Access	Limited	Some	Strong	Limited	Limited
Barriers	Adverse Perception of Travel	Strong	Strong	Some	Limited	Strong
	Cost	Limited	Some	Some	Limited	Some
	Inadequate Infrastructure Signage or Wayfinding Tools	Strong	Strong	Strong	Limited	Limited

User Needs/ Barriers	Type of Need/ Barrier	Wayfinding and Navigation	Assistive Technologies	Automation and Robotics	Data Integration	Enhanced Human Services Transportation
Barriers	Inadequate Transportation Options and Amenities	Limited	Some	Strong	Limited	Strong
	Lack of Technology Access	Some	Strong	Limited	Some	Some
	Lack of Travel Support/Customer Service	Some	Some	Strong	Strong	Limited

Source: Battelle

There are many themes and conclusions that emerged as a result of this research project. First and foremost, based upon the literature review, listening sessions at conferences, webinar(s) responses, and the discussion among participants at the workshop, persons with disabilities, Veterans with disabilities, and older adults clearly have significant needs and barriers to mobility. Although needs and barriers vary by sub-population and type of disability, several themes were observed to emerge regarding these needs and barriers, and potential technology solutions to address them. These overarching themes include:

1. **Information** for travelers with disabilities is a critical component for mobility. Having access to information prior to and during a trip was overwhelmingly supported by participants in project outreach activities, as well as documented in the literature review. Although this was the most cited need and barrier to improved mobility among persons with disabilities, it is interesting to note very few of the current “best practices” for transit identified through the literature review as having been adopted within the international and domestic transit community address the inaccessibility, relative unavailability, and lack of comprehensibility of information sources for travelers with disabilities. At the same time, however, participants in this research project were readily able to provide numerous specific examples of the types of technologies that could be utilized to address this need.

The topic of “Information” is an area that is ripe for pursuit by the U.S. DOT and others as relatively immediate technology insertion and would have a significant impact on improving mobility. Wayfinding and Navigation technologies tend to be the type of technologies that are most identified as being capable of meeting these needs and overcoming these barriers. Assistive Technologies and Enhanced Human Services Transportation technologies are also very relevant and should be pursued. There are certainly challenges with these technology options that include the reported lack of access to and utilization of technology information dissemination devices such as mobile phones, tablets, portable computers, etc. among persons with disabilities. As the trend in technology adoption by the general public continues upward, so too should adoption among persons with disabilities.

2. Travelers with Disabilities need travel **Options** before and during their travel. Many user needs and barriers can be directly attributed to the lack of or the perceived lack of travel options. In particular, travelers want to be able to have choices when planning their travel as well as have choices available during their travel to accommodate service conditions and other factors encountered. Veterans with disabilities and older adults, of which a significant

percentage reside in rural areas, often have only a limited selection of transportation options available. Automation and Robotics technologies may provide solutions to these needs by allowing more utilization of personal automobiles by persons with disabilities. Data Integration and Enhanced Human Services Transportation are technology focus areas that can provide technology solutions to enhance options by addressing, through coordination and data sharing, first/last mile integration and the lack of available transportation options.

Travelers with disabilities also want options when it comes to the facilities and amenities. They want to know prior to their trip what the transportation facility configuration is and the status of services. If unsuited or inoperable, they want alternative options for travel. Travelers with disabilities who are on a trip when services and/or amenities change status or become challenging for them to manage, want to be notified and provided with options so they may continue their travel. Receiving real-time assistance through technology options, such as a virtual personal assistant or an electronic guide dog, are examples of technology options cited as Wayfinding and Navigation as well as Assistive Technologies.

Having options with respect to travel, improves the overall perception of the transportation system as well as the overall quality of life for persons with disabilities. For older adults, it means that they have a much more likely ability to age-in-place as they can retain more of their independence by remaining mobile. All of the technology focus areas have a role to play in potentially providing travel options either before or during a trip and should continue to be explored.

3. More travel **Assistance** could be given to travelers with disabilities during their travel. In many cases, this assistance may be most easily provided by transit operators and transportation providers/staff. However, many of these individuals need increased levels of training that is specifically focused upon providing assistance to persons with different types of disabilities. Training of transportation providers alone will likely not resolve the need that persons with disabilities often have for assistance on topics such as wayfinding, trip planning, and notification of arrival at their destination/connection. Technology solutions such as mobile tactile or audible based applications for Wayfinding and Navigation would potentially provide solutions to the need for travel assistance. Other solutions that address the barrier of a lack of customer support/service include technologies that deploy Data Integration, such as crowdsourcing and social media applications, would also be beneficial.

Technology-based solutions that provide real-time assistance to travelers with disabilities include the use of a virtual electronic guide dog, wearable devices to provide course corrections, and even semi-autonomous technologies that detect when a traveler with disabilities has departed from their expected path and automatically begins to provide real-time guidance assistance through “on-demand virtual concierge service” technology, mobile applications, or other methods.

4. **Access** to transportation facilities could be enhanced through technology solutions, but current “best practices” have been effective in meeting this user need. Many of the current “best practices” within the transit industry involve improving the physical configurations and layouts of transportation facilities, so that they are more “accessible” to persons with disabilities. Curb cuts, raised strips indicating the edge of a transit platform, and connected and continuous pathways are examples of the types of best practices that have been deployed to improve access for persons with disabilities. These types of best practices and corresponding changes within the transportation system seem to be working. Needs and barriers associated with a lack of access were consistently cited lower than all other needs and barriers for mobility.

There were a relatively small number of potential technology solutions that were identified as part of this User Needs: Stakeholder Engagement project that could contribute to improving access, although these solutions also could be typically be considered as “assistive” technologies. For example, assistive devices, such as a white cane with environmental sensors to detect hazards (e.g. black ice) or tactile navigation/information device for individuals who are deaf-blind, or proximity-based public announcements through text-based messaging are the type of technologies that were identified. Autonomous systems such as fully autonomous vehicles would also improve access to the transportation system.

Overall, further technology insertion and research into this user need should occur as a side benefit of improvements made by technologies in one of the other three user need/barrier areas.

Overall, the findings of this project demonstrate that mobility improvements for persons with disabilities, Veterans with disabilities, and older adults are needed. Current “best practices” do not appear to address most of the identified user needs and barriers to travel. The technology options within each of the five technology focus areas identified by U.S. DOT as: (1) Wayfinding and Navigational Solutions, (2) Assistive Technologies, (3) Automation and Robotics, (4) Data Integration, and (5) Enhanced Human Services Transportation have significant potential to address many of the specific user needs and barriers to improved mobility and should continue to be explored and prototyped as part of Phase II of ATTRI.

Chapter 1 Background and Objectives

The Accessible Transportation Technologies Research Initiative (ATTRI) is a joint U.S. Department of Transportation (U.S. DOT) initiative, co-led by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA), with support from the Intelligent Transportation Systems (ITS) Joint Program Office (JPO), National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR), and other Federal agencies. ATTRI's mission statement defines the Initiative's purpose, the people it serves, and its primary objectives:²

The mission of ATTRI is to transform the mobility of travelers with disabilities by providing the capability to reliably, safely and independently plan and execute their travel. ATTRI identifies, coordinates, develops, and implements new integrated solutions in advancing accessible transportation and universal mobility.

In consultation with its stakeholders, partners, and customers, the ATTRI leadership team developed the following goals and associated objectives to guide the Initiative toward achieving the vision of affordable and accessible transportation for all:³

- **Identify stakeholders and assess user needs** – Determine the targeted groups for the ATTRI research and examine their distinct user needs.
- **Harness technological innovation for accessible transportation** – Prioritize which technologies to develop in the next 3-5 years and select technologies for future long-term investment.
- **Improve transportation systems integration** – Consider how ATTRI technologies integrate with existing systems; improve how people with disabilities including Veterans and older adults access transportation; and change transportation systems for the betterment of all.
- **Coordinate with key partners** – Work collaboratively with other Federal agencies and research partners supporting this effort with their funding and expertise to share results and provide guidance on accessible transportation policy.

Although there are many different aspects of mobility and the associated role of transportation, ATTRI was launched with the specific focus of seeking to identify, develop, and deploy new transformative applications or systems to increase mobility for travelers with disabilities. This segment of the traveling public includes persons with disabilities, Veterans with disabilities, and older adults. The focus of ATTRI is research to improve the mobility of travelers with disabilities by using ITS and other emerging technologies developed across a wide range of governmental entities. ATTRI seeks to leverage the wealth of prior research to identify, develop and deploy new transformative applications or systems to increase mobility for travelers with disabilities.

² U.S. DOT Accessible Transportation Technology Research Initiative 2014-2019 Strategic Plan, 2014.

³ U.S. DOT Accessible Transportation Technology Research Initiative 2014-2019 Strategic Plan, 2014.

Success of ATTRI is highly dependent upon understanding the needs and barriers to mobility by travelers with disabilities. As such, stakeholder feedback that can be used to validate the overall ATTRI goals, objectives, and direction is critical to the mission's success. Stakeholder engagement can take many forms and should involve as wide a segment of the populations of interest as possible. The objective of this project is to conduct a portion of the stakeholder engagement that the ATTRI staff are conducting as part of the overall initiative.

In this User Needs: Stakeholder Engagement ATTRI task, stakeholders were members of the disability community including those with physical disabilities, vision and hearing disabilities, and cognitive disabilities; Veterans with disabilities; and older adults that are “consumers” of the transportation system. The perspective of these stakeholder groups was enhanced through the engagement of “providers” within the transportation community including transportation agency executives, managers, and operators; private sector vendors; and private sector product and application developers. Stakeholders also included representatives from the research community such as professors and researchers from national, non-profit organizations who are focused on studying and improving universal access to transportation for people with disabilities under the Federal laws and guidelines.

Three focused sets of activities were conducted in this project to solicit feedback and information from stakeholders. First, a literature review was conducted to review, analyze, and summarize past research on and the experiences of stakeholders in addressing barriers to safe, reliable, and independent transportation. Secondly, a series of webinars were conducted to gain input from people with disabilities, Veterans with disabilities, and older adults (including their caregivers and advocates) to identify specific transportation needs, discuss mobility challenges, and engage in a dialogue about how technologies may address their needs. Finally, an in-person workshop was conducted to obtain feedback on how emerging technologies may address the identified needs and barriers of the target populations consisting of people with disabilities, older adults, and Veterans with disabilities in order to provide better travel solutions. Another goal of the workshop was to validate the results of the webinar series that were conducted prior to the in-person workshop.

To complement the workshop, presentations and “listening sessions” were conducted at three conferences to inform participants about ATTRI and gain additional feedback on user needs and barriers. Presentations were made at the following conferences:

- California State University, Northridge 30th Annual International Technology and Persons with Disabilities Conference on March 5, 2015;
- Community Transportation Association of America Implementing Technology in Community Transportation on June 2, 2015; and
- Association for Education and Rehabilitation of the Blind and Visually Impaired Conference on Vision Loss in Older Adults and Veterans on November 5, 2015.

Although participation in the listening sessions at these conferences was relatively low, important information from those stakeholders that participated was found to be generally consistent in identifying the user needs and barriers to mobility that were noted by participants in the larger, dedicated workshop and webinars.

Contextual Background

Access to transportation is an extremely important policy issue for people with mobility needs. Persons with disabilities, Veterans with disabilities, and older adults have the same travel expectations as individuals with unrestricted mobility. They expect to have a variety of transportation options, travel safely and comfortably, and arrive to their destination without any difficulties. However, based on research, polls, and anecdotal experiences from these demographic groups, seamless and barrier-free transportation is uncommon.

Since the enactment of the Americans with Disabilities Act (ADA) in 1990, significant improvements have been made for persons with disabilities in transportation. In February 2004, Presidential Executive Order on Human Service Transportation Coordination (Executive Order 13330) requested the establishment of the Federal Interagency Transportation Coordinating Council on Access and Mobility to enhance accessibility and mobility for persons who are transportation disadvantaged, especially individuals with low-incomes, people with disabilities, and older Americans.

In July 2009, the United States (U.S.) signed the United Nations (UN) Convention of the Right of Persons with Disabilities (CRPD) indicating an intention to be bound by the convention. CRPD is an international disability treaty that was motivated by U.S. leadership to recognize the rights of people with disabilities. The CRPD is a framework for creating legislation and policies around the world that embrace the rights and dignity of all people with disabilities. However; in 2012, the ratification of the CRPD fell short of the U.S. Senate votes required. With the end of New Freedom⁴ as a distinct program under Moving Ahead for Progress in the 21st Century (MAP-21) Act, the need for strategic improvements in accessible transportation technologies research is especially needed.

The advent of new roadside and computing technology has opened new ways of addressing the mobility needs of persons with disabilities. Innovations like Intelligent Pedestrian Signals and Other Intelligent Wayside Technologies, talking signs and bus stops, personal wayfinders, and built-environment navigation aids, and location-based services all promise some immediate options to enhance the accessibility of transportation. Connected and autonomous vehicles will bring additional capabilities in the not too distant future.

Understanding the Needs of Persons with Disabilities

In 2010, the U.S. Census reported that approximately 56.7 million people in the U.S. (18.7 percent of the U.S. population) had some type of disability. In a similar study,⁵ researchers found that over 6 million people with disabilities have difficulties obtaining the transportation they need, and nearly one-third of people with disabilities reported having inadequate access to transportation. This is an important consideration for transportation agencies and officials, as transportation has long been thought to be instrumental in enhancing access to education, jobs, healthcare, and the overall

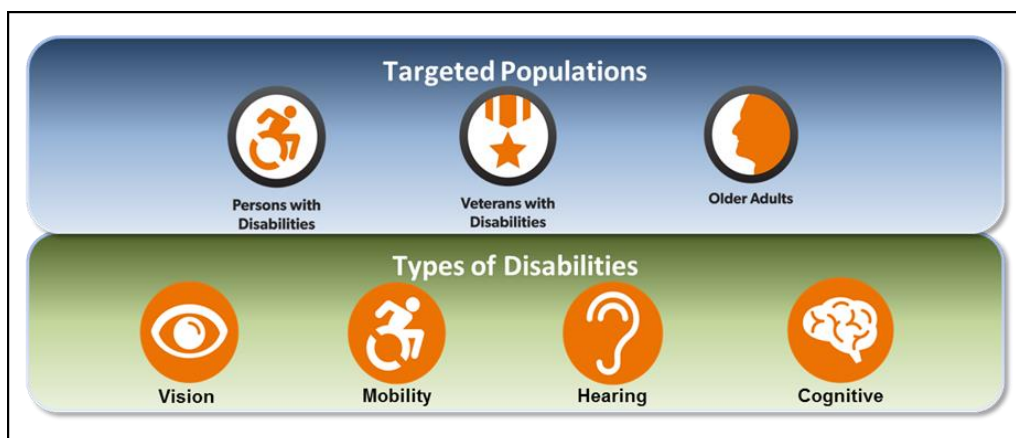
⁴ Combined into the Section 5310 program, Enhanced Mobility of Seniors and Individuals with Disabilities (MAP-21).

⁵ U.S. DOT Bureau of Transportation Statistics, Issue Brief: Transportation Difficulties Keep Over Half a Million Disabled at Home, 2003
http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/special_reports_and_issue_briefs/issue_briefs/nuber_03/html/entire.html

economic health of a community.⁶ This extends to persons with access and functional needs, including persons with disabilities, Veterans with disabilities, and older adults, a correlation that has been noted by many researchers including Rosenbloom, 2007.⁷ Currently, within this segment of the population, there is a 63 percent unemployment rate, with half of the household income and three times the poverty rate of people without disabilities, lending some credence to the relationship between disability and economic indicators.

The number and overall percentage of the population that are comprised of persons with disabilities and/or reduced mobility are expected to grow over the next 30 years,⁸ due to two primary factors: (1) rise of Veterans with disabilities, and (2) aging of “baby boomer” generation. To date, 1.4 million U.S. servicemen and women have been deployed to war zones, and more than one-third of recent Veterans report having a service-connected disability. Another contributing factor is the aging of the “baby boomer” generation and the ability of this, the largest segment of the population, to access transportation; particularly as they become unable to continue to operate their personal automobile and become reliant upon public transportation. In 2004, 35 million people were age 65 or older in the United States. That number is expected to more than double by the year 2025, to over 72 million.

Eliminating the barriers associated with transportation by developing new technology solutions to ease travel will give travelers with disabilities greater options and improved access to healthcare, education, employment, housing, and community services. With this vision in mind, sessions were held in January 2014 with U.S. DOT staff and key stakeholders that identified the strategic focus for ATTRI for three (3) subpopulations of interest and four (4) types of disabilities (see Figure 1-1).



Source: U.S. DOT

Figure 1-1. ATTRI Targeted Populations and Types of Disabilities

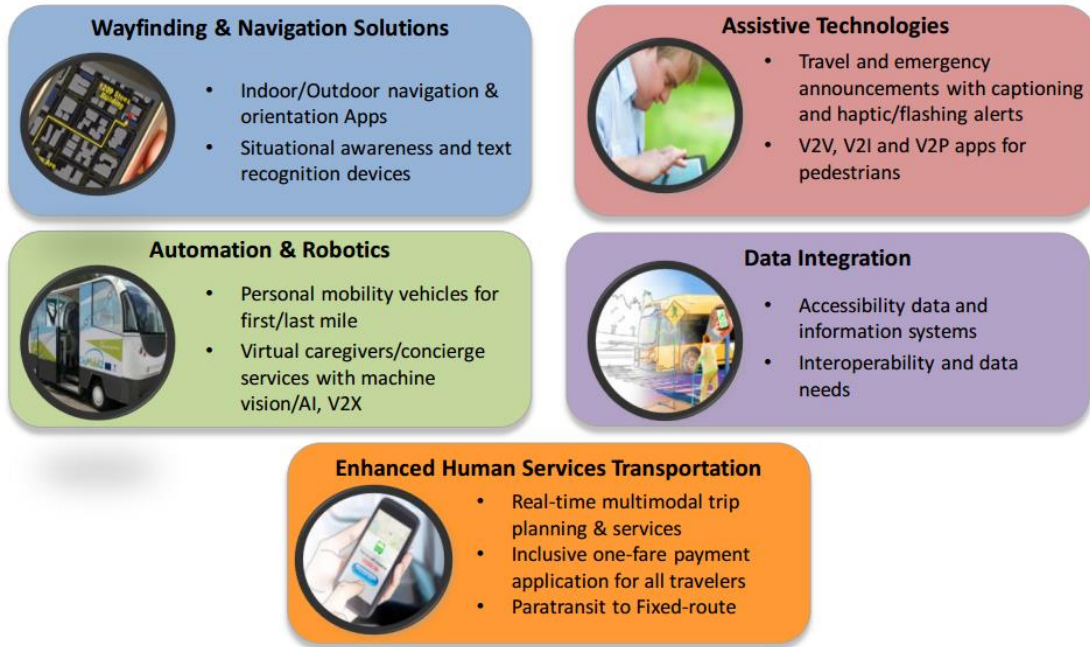
Following these visioning sessions, as well as other preliminary research and stakeholder input, ATTRI staff identified five (5) technology groups as potential ATTRI application areas (see Figure 1-2). Within these areas, the specific technologies for consideration ranged across a broad spectrum

⁶ Thomas W. Sanchez, “The Connection Between Public Transit and Employment,” 1998, available at: <http://reconnectingamerica.org/assets/Uploads/Public-Transit-Employment.pdf>

⁷ Rosenbloom, Sandra, “Transportation Patterns and Problems of People with Disabilities,” Contained within *The Future of Disability in America*, Washington (DC): National Academies Press (US); 2007

⁸ Cornell University, 2012 Disability Status Report (United States), 2012, http://www.disabilitystatistics.org/StatusReports/2012-PDF/2012-StatusReport_US.pdf

including emerging technologies such as vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications, autonomous vehicles, robotics, ITS sensing technologies, machine vision, smartphones and other personal mobility devices, and other wireless sensors and devices.



Source: Thinkstock/U.S. DOT

Figure 1-2. Potential ATTRI Technology Areas

ATTRI Technology Areas

Each ATTRI Technology Area represents a grouping of technologies, applications, and sensors where research may be needed to identify those needs, barriers, and technologies that persons with disabilities encounter in their daily lives. Although distinct areas, there are common, consistent influences within each technology area including the emergence and adoption of increased computational power in automobiles, mobile devices, sensors, and applications; many of which would not have been economically or practically feasible only a decade ago.



Source: 123RF, Battelle

Wayfinding and Navigation Solutions

This area consists of exploration and development of situational awareness and assistive navigation solutions that can provide obstacle avoidance and intelligent wayfinding capabilities for indoor and outdoor environments. These solutions assist with waypoint navigation, path planning, and advanced warning of events by using Global Positioning System (GPS), Geographic Information Systems (GIS), and ITS equipment and technologies. Such applications can recognize and detect stationary objects (e.g., doors, elevators, stairs, crosswalks, and traffic lights), read and recognize important text and signage based on a user's query, and detect, track, and represent moving objects and dynamic changes to a traveler's environment (e.g., people, shopping carts, doors

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Intelligent Transportation Systems Joint Program Office

opening, and moving vehicles). Wearable sensors, such as cameras, three-dimensional orientation devices, smartwatches, and pedometers, may be used in conjunction with a display unit to provide auditory and tactile guidance.

ITS and Assistive Technology



Source: 123RF

This area explores a broad range of wireless and sensor-based communications and information technology employed in ITS together with a combination of additional assistive technologies to create new innovative accessible transportation solutions. The associated technologies include the traditional accessible, assistive, and adaptive devices that currently help with daily living activities and new nomadic or carry-on devices. Together, these technologies will help track the user's movements, infer map information, and discover key sensor signatures to create routes and provide information in different accessible communication formats – audible, tactile, and haptic. The devices used may include new innovations from the “Internet of Things (IoT)” being applied to wearable technology, such as wrist bands, glasses, clothing, or others. These technologies also integrate with vehicles, infrastructure, and pedestrians using Dedicated Short Range Communication (DSRC) or other communication technologies to provide V2V, V2I, and vehicle-to-pedestrian (V2P) communications allowing for connectivity throughout a trip. This area also explores other emerging technologies within the connected vehicles, connected automation, and connected cities initiatives under the U.S. DOT's connected vehicle research program.

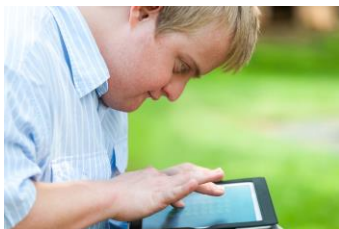
Automation and Robotics



Source: 123RF

Automated vehicles and robotics are expected to improve mobility for those unable or unwilling to drive and enhance independent and spontaneous travel capabilities for travelers with disabilities. One area of particular interest among public transit agencies is exploring the use of vehicle automation to solve first mile/last mile mobility issues, possibly providing connections for all travelers to existing public transportation or other transportation hubs. Applications in this area also include collaborative robots that assist with activities in daily life such as walking and also work with individual travelers and human transportation services to provide related concierge services at different stages of their travel, thus, improving personal mobility across the transportation network. Machine vision, Artificial Intelligence (AI), assistive robots (potentially partially humanized), and facial recognition software to solve a variety of travel related issues for persons with disabilities in vehicles, devices, and terminals are also included to create virtual caregivers/concierge services and other such applications to guide travelers and assist decision making.

Data Integration



Source: 123RF

This technology area includes solutions that enable the integration of data and information systems to create new accessible transportation applications. This technology area has two main aspects: information that travelers with disabilities need, and information that travelers with disabilities can provide. Travelers with disabilities need in-depth accessibility information about points of interest (POIs), infrastructure, facility amenities, and potential obstacles, integrated with maps and other information for their intended route. Conversely, a traveler with accessibility needs can provide his or her specific information to build

a standardized user profile that allows for location based services both locally and nationally. Based on the user profile, applications can be developed to alert relevant authorities in advance of a user's trip requiring special accommodations, such as a wheelchair accessible transit vehicle needed.

Enhanced Human Service Transportation



Source: 123RF

The focus of this technology area is real-time, multimodal trip and services planning and traveler decision support applications that assist travelers with finding and choosing accessible transportation solutions that best meet their mobility needs. This may include pre-trip planning and information that integrates multi-modal options into a complete trip from origin to destination. Applications in this area include an integrated payment system where travelers can use the same smart card or mobile app to pay for various types of transportation, mobility options, and parking.

Other applications of interest include linking paratransit, demand-response transportation, and fixed-route transit to increase flexibility and options for travelers with disabilities.

Chapter 2 Methodology and Summary of Data Collected

Three focused sets of activities were conducted in this ATTRI User Needs: Stakeholder Engagement task to solicit feedback and information from stakeholders: a literature review, a series of webinars, and an in-person workshop. Each of these efforts was designed to provide information on many of the same topics – though using different mediums and techniques. Results from each activity were used as initial inputs for the remaining activities, allowing for the development of common themes and gathering of detailed information from stakeholders. The literature review, which was conducted first, provided insights into the historical perspectives of stakeholders as reported on by other researchers. This information directly informed the development of discussion topics and focus areas for the webinars. In turn, the webinars provided additional context and information that was then utilized and explored as part of an in-person workshop.

While providing important information to the ATTRI program, it is also important to note that prior to and continuing throughout the course of the project, ATTRI staff were engaged in many other research activities and stakeholder engagements including other webinars, workshops, and “online dialogue” opportunities,⁹ as well as conference presentations and “listening sessions” held during conferences attended by stakeholders. The following only presents the methodology and data collected as part of the activities conducted specifically for this project, though many of the topics, approaches, and methodologies were modeled after other activities conducted by ATTRI staff or their delegates.

The following sections summarize the methodology that was used and the data collected during each component of the research project. A synthesis of the information across all three of the data collection activities is provided in the next Chapter of this report.

Literature Review

The literature review was the first data collection activity conducted for the project and helped to set the stage for the remaining two outreach activities by providing a summary of the information gathered from stakeholders as reported by past and present researchers. The list of references identified by the literature review can be found in APPENDIX B.

Literature Review Methodology

The goal of the literature review was to collect, analyze, and summarize past research on the experiences of stakeholders in addressing barriers to safe, reliable, and independent transportation. The analysis includes experiences, challenges, success stories, best practices, and lessons learned. Materials from a range of service and advocacy organizations including, but not limited to Easter Seal’s Project ACTION, National Center for Senior Transportation, United We Ride, National Council

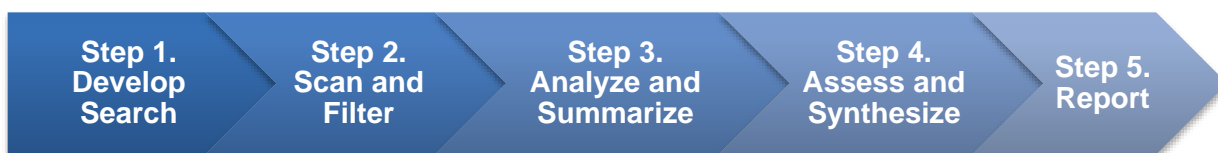
⁹ Elizabeth Greer, Drennan Hicks, Carolina Burnier, Rachel Beyerle; “Accessible Transportation Technologies Research Initiative (ATTRI): Online Dialogue,” 2014, Noblis under contract with FHWA DTFH61-11-D-00018. Available as Report: FHWA-JPO-14-147

on Independent Living, the Association of Area Agencies on Aging, the Department of Veterans Affairs, and the American Association of Retired Persons (AARP) were also considered and used as inputs.

The literature review provides information on current, emerging, and future technologies that identify and address user needs for unrestricted transportation. Both domestic and international publications were reviewed and summarized in tables providing the title, source agency or author(s), date (when available), a link to the source, a brief synopsis of the article, and any general comments about the publication (e.g., white paper, technical report, etc.). These publications include a variety of formats such as fact sheets, research reports, white papers, and articles from newspapers, journals, and websites. The research team also included some international sources as the transportation needs of people with disabilities that are universal. Since the review involves technology and technological advances, and considering the short lifecycle in today's rapidly-advancing technology environment, the research team avoided incorporating information from literature prior to 2005, except for a few literature sources that were closely relevant to the subject.

A traditional literature search was conducted using published literature, online information sources, and other reference material pertaining to travel needs for persons with disabilities, Veterans with disabilities, and the older adult population. The emphasis of the search was on the user needs of travelers with vision, hearing, mobility, and cognitive needs within the context of travel to work, medical facilities, school, and travel for leisure or spontaneous travel using various modes of transportation.

Figure 2-1 provides the process that was used for searching, reviewing, and compiling the literature.



Source: Battelle

Figure 2-1. Systematic Literature Review Process

Literature Review Step 1 and Step 2: Develop, Scan, and Filter Literature from Electronic Databases

Step 1 involved an extensive keyword search focused on ways technology addresses the transportation needs of persons with disabilities, Veterans with disabilities, and older adults. An initial list of keywords and phrases was used to search the post-2005 literature. However, as the search progressed, other related keywords/phrases were included to find other relevant literature until all sources were exhausted within the given scope and time allocated for this task. Online searches, using Google, started with potential stakeholder sites and organizations that are likely to have the most relevant information developed in the past two to five years. Other literature resources were located by searches of electronic journals and databases, as well as thousands of print books and journals focused on scientific and technical information. In particular, the U.S. DOT Transportation Research Information Services (TRIS) Library was scanned for relevant research and publications as were other known repositories for relevant literature including, but not limited to:

- Carnegie Mellon Robotics Institute
- Community Transportation Association of America
- Easter Seals Project Action

- GeoAccess
- National Academies Press
- National Institute on Aging
- Rehabilitation Engineering Research Center on Accessible Public Transportation
- Transportation Research Board (TRB)
- United We Ride.

The primary focus of ATTRI is the mobility of individuals with disabilities; however, the term “disability” is highly inclusive. According to the World Health Organization (WHO), the term “disabilities” includes impairments, activity limitations, and participation restrictions. As defined by the WHO, “an impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations.”¹⁰ Similarly, the Centers for Disease Control and Prevention classify several types of disabilities, including vision, movement, thinking, remembering, learning, communicating, hearing, mental health, and social relationships. For the purposes of this report, the disability types that most impact an individual’s mobility have been identified as visual, hearing, cognitive, and physical.

According to a recent Congressional Research Service (CRS) Report on eligibility for Veterans’ benefits, a Veteran is “a person who served in the active military, naval, or air service, and who was discharged or released therefrom under conditions other than dishonorable.”¹¹ Genuine and accurate military service records which must include length, time and character of the service, are used to validate Veteran status. Importantly, not all types of service are considered active military service for the purposes of being considered a Veteran. The length of service criteria is generally 24 months of continuous, active duty or the “full period” for which the service member was called or ordered to active duty. The discharge criteria requires that an individual be discharged or released from duty “under conditions other than dishonorable.” “Wounded Warriors” is another commonly identified group of military persons that have suffered wounds, illnesses, or injuries incurred in the line of duty. The eligibility criteria to be considered a Wounded Warrior varies for each branch of the service, but generally is broad in inclusion – it is not typically restricted to only combat injuries.

For the purpose of this project, older adults are defined as individuals aged 65 and older. This definition is consistent with the Administration on Aging’s definition of older adults. While ATTRI’s primary focus extends to individuals with disabilities, older adults are living longer, healthier and more active lives, and it is expected that the likelihood of a person developing a disability, chronic illness, or mobility needs increases with age. As a result, the increase in the older adult population is of great interest to ATTRI, as it seeks to guide the development of technologies that increases their quality of life by improving their mobility options and allowing them to travel safely, efficiently, and independently.

Literature Review Steps 3-5: Analyze, Synthesize, and Report

Step 3 involved using a standard format and structured review form to individually analyze and summarize the selected literature in detail with respect to the subject initiative, and to develop an annotated bibliography. Step 4 involved synthesizing the detailed summaries of the selected

¹⁰ World Health Organization, *Health Topics: Disabilities*, <http://www.who.int/topics/disabilities/en/>. World Health Organization, *Health Topics: Disabilities*, <http://www.who.int/topics/disabilities/en/>.

¹¹ Moulta-Ali, Umar, *Who is a ‘Veteran’? – Basic Eligibility for Veterans’ Benefits*, Congressional Research Service, February 13, 2015.

literature, combining the findings categorized by user needs and user groups, and assessing the findings. Step 5 involved composing the interim report of the literature reviewed to inform the ATTRI strategy and describing the user needs and best practices.

Literature Review Summary of Data Collected

At the conclusion of the literature review, several hundred different publications had been reviewed for relevance. Ultimately, abstracts and data from 155 publications were compiled using a common literature review abstraction form for analysis and summary as part of this project. During this abstraction process, it became clear that different authors and/or groups had varying definitions of the types and characteristics of persons that comprise each sub-segment of the population. One useful aspect of the literature review was to compile a consistent working definition for each of the three segments as described below.

Characteristics of Persons with Disabilities

The estimates reported by the U.S. Census population report include three domains of disability as communicative, cognitive, and physical. People with communicative disabilities include individuals who are blind, deaf, have difficulty seeing or hearing, and individuals with speech impediments to the point of being difficult to understand. Cognitive disabilities include learning, intellectual, cognitive, and developmental disabilities; Alzheimer's disease, senility, or dementia; and other cognitive or emotional conditions that seriously interfere with the individual's everyday activities. Physical disabilities include use of a wheelchair, cane, crutches, or walker; difficulty walking a quarter of a mile, climbing a flight of stairs, lifting something comparable to a 10-pound bag of groceries, grasping objects, or getting in and out of bed; and a number of specifically listed physical and medical conditions such as arthritis, cancer, missing limbs, respiratory problems and stroke, amongst others. Generally, the American Community Survey (ACS)¹² is most often used to define the segment of the population that has a disability. The ACS captures, through a series of six questions, information from respondents on visual, hearing, cognitive, mobility, self-care, and independent-living.

Characteristics of Veterans with Disabilities

Due in part to the wide range of ages and eras in which they served, Veterans with disabilities make up a very heterogeneous segment of the population with different characteristics, needs, and preferences that vary significantly by gender, age, and population density. The following highlight a portion of these differences:

- **Differences by Gender.** More Post-9/11 female Veterans lived in poverty, used food stamps and had no income compared to their male colleagues. However, more Post-9/11 male Veterans with a service-connected disability used VA health care and had less health insurance coverage than their female colleagues.¹³
- **Differences by Age.** The poverty rate for Veterans ages 18 to 34 years old is higher than those between the ages of 35 and 54 years old. The poverty rate for Veterans with disabilities is higher than for non-Veterans with disabilities for both age groups. Gulf War Veterans have higher poverty rates in comparison to other periods of service except for peacetime. The poverty rate for Veterans with

¹² American Community Survey, 2015, U.S. Bureau of Census. Data Available at <https://www.census.gov/programs-surveys/acs/>

¹³ Profile of Post-9/11 Veterans: 2012

http://www.va.gov/vetdata/docs/SpecialReports/Post_911_Veterans_Profile_2012_July2015.pdf

disabilities is higher than non-Veterans with disabilities for ages 55 to 64, but less than non-Veterans with disabilities 65 and over.¹⁴

- **Differences by Population Density.** Veteran poverty rates are not uniform across the United States but clustered in high poverty rate states in the Northwest and Southeast. Also, a higher percentage of Veterans in rural areas reported having at least one disability compared with non-Veterans living in rural areas. A slightly higher percentage of Veterans residing in rural areas had a service-connected disability rating greater than 50 percent compared with urban Veterans. In contrast, urban Veterans had a slightly higher representation in the 0 to 40 percent service-connected disability ratings compared with rural Veterans.¹⁵

User Needs Identified in the Literature Review

Among those persons in the general population with a disability, the user needs are often strongly associated with their type of functional disability, which was a common theme throughout the literature review. Key needs of persons with disabilities identified consistently in the literature include:

- Those with a **visual disability** have a heavy reliance on public transportation including on-demand and paratransit services and, therefore, need:
 - Availability of public transportation resources including fixed service, on-demand and paratransit service.
 - Information about the public transit system in accessible form that can be used with screen readers.
 - Audio announcements on and around public transportation facilities such as transit hubs, platforms, etc. and vehicles to provide both static and real-time information.
- Those with a **hearing disability** require non-audible means to receive information such as visual displays of upcoming stations/stops and emergency notifications. Additionally, these persons need transit operators to have basic non-audible communication skills or have the ability to achieve communication with the operator through advances in technology such as text-to-speech. These types of information mechanisms need to be included in passenger vehicles at an affordable cost to the user alleviating the requirements for special licensing.
- Those with a **cognitive disability** require information in a fashion that is simplified and made easier for their consumption. Simplified navigational guidance/instructions and information on operational aspects of public transportation are two particular areas that need improvement. Technologies that provide real-time, interactive assistance are needed by this user group as additional training for transit operators.
- Persons with **mobility disabilities** are typically constrained by the physical environment within the transportation system. Physical and architectural components of public transportation facilities need additional design considerations to make them more accessible, while assistive technologies that

¹⁴ http://www.va.gov/vetdata/docs/SpecialReports/Veteran_Poverty_Trends.pdf

¹⁵ http://www.va.gov/vetdata/docs/SpecialReports/Rural_Veterans_ACS2010_FINAL.pdf

provide real-time updates of inoperable transit system components and alternatives have been identified as needed. Priority labeling of seats, waiting areas, etc. are typically called out as needs in the literature review for this segment of the population.

The literature review on the transportation needs of Veterans with disabilities, Wounded Warriors and their families comes primarily from Federal agencies that consistently reflect the growing awareness that the lack of accessible and affordable transportation has adversely affected healthcare, education, employment, and general quality of life for these Veterans with disabilities and their families. As with older adults and persons with disabilities, Veterans with disabilities have many of the same fundamental user needs. However, in research reports generated by various government agencies, Veterans have reported that they:

- Have problems accessing VA medical services due to distance, lack of parking facilities, transportation options, etc.
- Are especially challenged with transportation when they reside in rural areas (40 percent of Veterans) due to the long distances required to travel to receive medical attention and overall poorer health.¹⁶
- Rely upon transportation services that are typically not coordinated with existing community and public transportation services.
- Struggle with volunteer-based transportation services that do not include vehicles that are accessible to Veterans in wheelchairs.
- Experience excessive wait times for scheduling trips or for the scheduled transportation to arrive.
- Are unaware of other travel options or best practices in Veterans' transportation services.
- Experience a lack of uniformity and consistency in the services that they receive.

These needs are not insignificant; Veterans who miss medical appointments exhibit higher rates of depression, poor health care access, socialization problems, and suicide.

While much of the literature review on Veterans with disabilities is focused upon accessibility to healthcare or transportation to and from medical care, some literature review also note that the transportation needs of Veterans with disabilities are also associated with a need for education, shopping, work, and social functions. These activities are needed for quality-of-life and are important to mental wellness, as well as physical needs.

Characteristics of Older Adults

“Older Adults,” as defined for this project as persons over the age of 65, are very diverse in their individual requirements and level of mobility. One common characteristic among this segment of the population that is often associated with mobility is defined by the person’s ability to “age in place.” As

¹⁶ Federal Transit Administration. (2011). Research Results Digest 99. Retrieved from http://www.trb.org/TCRP/Blurbs/Improving_Mobility_for_Veterans_165243.aspx

defined by Farber, et. al., aging in place is “the ability to live in one’s own home and community safely, independently, and comfortably, regardless of age, income, or ability level.”¹⁷

As each person is unique, so too is their ability to “age in place” and their resultant mobility needs and level of disabilities that limit their mobility. Some older adults remain completely independent and continue to drive independently, while others may be able to drive, but require vehicle modifications and/or some advanced technologies to assist them. Another group of older adults have transitioned away from driving altogether, sometimes due to age-related disabilities, and rely fully on public transportation and a variety of transportation services. Finally, there are older adults who also rely on services and technologies, not only for transportation, but for basic day-to-day mobility as well.

In many respects, older adults have similar needs as described above by persons with disabilities, because as people age, many of the challenges they face involve loss of hearing, vision, mobility movement, and cognitive skills. However, the size and geographic distribution of older adults presents new needs and challenges, as roughly one-half (47.2 percent)¹⁸ of older adults reside in rural areas that may not be typically “covered” as extensively with public transportation options as those individuals who reside in urban or suburban areas. In these rural areas, destinations are often too far to walk, public transportation is scarce or unavailable, taxi service is costly, and special services can be limited. This suggests that perhaps one dominant need among this segment of the population is simply better access to the public transportation system. A recent study conducted for the Transportation Research Board provides additional clarity for these needs. Focus groups among older adults living in rural areas indicated a desire for flexible service (e.g., on-demand and without a 24 hour wait), reliable start/stop times, and door-to-door service.¹⁹

International Standards, Initiatives, and Activities

The user needs among persons with disabilities, Veterans with disabilities, and older adults vary greatly and are individualistic in nature. Nevertheless, there are commonalities among these population segments, which are also recognized and incorporated into those “best practices” that have been adopted by the transit industry in an attempt to meet those needs. These best practices can be found among transit agencies in the U.S. and throughout the world. These practices were launched in the U.S. by the passage of the Americans with Disabilities Act (ADA) in 1990, and other countries have adopted similar standards and conventions to enable equal opportunities for people with disabilities. In particular, The United Nations (UN) adopted the following guidelines and standards:

- World Programme of Action Concerning Disabled Persons, adopted in 1981
- Standard Rules on the Equalization of Opportunities for Persons with Disabilities, adopted in 1993
- Declaration on the Rights of Disabled Persons, adopted in 1995
- Convention on the Rights of People with Disabilities (CRPD), adopted 2006.

¹⁷ Farber, Nicholas, Shinkle, Douglas, “Aging in Place: A State Survey of Livability Policies and Practices”, National Conference of State Legislatures (2011).

¹⁸ National Association of Area Agencies on Aging

¹⁹ TCRP 82: Improving Public Transit Options for Older Persons –The Demographic Challenge, available at: http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_82v2a.pdf

In more recent history, 20 European organizations united to establish the first Mobility as a Service (MaaS) Alliance (October 2015).²⁰ This new initiative will work towards a common approach to MaaS through public and private stakeholder collaboration, providing the basis for the economy of scale needed for successful implementation in Europe. MaaS is a mobility distribution model that services a customer's transportation needs over a single interface by a service provider. In addition to the MaaS Alliance, the European Congress has developed another program that serves as an information system to assist in the travel and transportation of individuals with disabilities and older adults. The Transport Using Technologies Leads to Economic Efficiency (TURTLE) Program provides real-time transportation service information including location of the service, route information and the physical accessibility of the mode of transportation to any traveler, with or without a disability. In Japan, a cross-ministerial Strategic Innovation Promotion Program (SIP) was established in June 2013 followed by the Automated Driving for Universal Services (ADUS) project in 2015.²¹ Other Asian countries have followed suit, most notably in Singapore with the 2014 initiation of the Autonomous Vehicle Initiative (SAVI).

All of these domestic and international standards, initiatives, and activities provide a broad crosswalk of best practices that have been and will continue to be adopted to address the needs of these segments of the populations.

Best Practices Identified in the Literature Review

With the inclusion of both domestic and international practices, there are a large number of different standards, regulatory provisions, and practices that have been introduced and adopted by transit agencies throughout the world. Many of these solutions and/or best practices are focused upon operations and do not involve technology. This observation is most predominant among the literature review discussing Veterans with disabilities and their transportation needs, barriers, and best practices. Other than specific technological solutions such as the "One-Call, One-Click Transportation Research Centers" and the potential use of Radio Frequency Identification Devices (RFID) in VA Smartcard IDs as a means to pay fares and track transit usage, there is very little discussion on technological solutions in general. Absent from the literature review are notable technology advances and solutions such as fare systems, wayfinding, connected environments and vehicles, and autonomous/robotic vehicles. Nevertheless, it is still important to consider non-technology based best-practices for these population sub-segments, as technology is becoming pervasive in society, and even those things that are traditionally "fixed" such as maps, information signs, etc. are being replaced by a technology alternative. This raises the potential for a technology solution to enhance and improve an existing best practice.

Best practices identified for persons with disabilities, Veterans with disabilities, and Older Adults in the literature include:

- **Pedestrian Footways**
 - Ensure firm, even surfaces for people with walking difficulties.
 - Ensure sufficient width and height in places where pedestrian traffic is high and for persons who are blind or have low vision who may not see overhanging branches or signs.
 - Walkways should be simple with benches, signs, trash bins out of the pedestrian walkway.

²⁰ <http://murer.com/pdfs/articles/odtt.pdf>

²¹ <http://www.sip-adus.jp/workshop/about/index.html>

- Place rest areas along walkways at regular intervals.
- **Street Crossings**
 - Crosswalk design should include time to cross for people with walking disabilities.
 - Center islands are helpful on crosswalks that span multiple lanes.
 - Curb ramps should be used wherever sidewalks meet the crosswalks.
 - Tactile surfaces at the edge of crosswalks can warn someone with a vision disability of potentially departing the crosswalk.
- **Vehicle Design and Operation**
 - Bus entrances can be improved with handrails and grab handles.
 - Priority seats should be close to the driver and entrances/exits.
 - Aisles should be wide enough for passengers to move about freely.
 - Stop request buttons should be positioned so that passengers can reach them while seated.
 - Drivers should consistently stop near the curb and next to the stop pole.
 - Agencies/governments should consider fare subsidies for older adults and people with disabilities.
 - Low floor buses or buses with mechanical lifts should be utilized to allow for full wheelchair access. Ensure enough space to accommodate wheelchairs movement positioning into the wheelchair seating areas.
- **Door-to-Door Services**
 - Use smaller vehicles for cost-effectiveness.
 - Use contracted private operators such as taxi companies or Uber™ with wheelchair accessible vehicles to reduce agency costs.
 - Make reservations available through several platforms – telephone, through social services agencies, and websites. Allow enough time for trips to be assigned to a vehicle.
 - Pre-register passengers to ensure only eligible passengers are using the service.
 - Schedule trips in batches to lower cost per trip.
 - Utilize coordination and integration software, which coordinates transportation among multiple agencies.
- **Service Routes and Operations**
 - Use medium size vehicles with higher capacities than door-to-door services.
 - Plan stops near appropriate destinations to reduce walking distances.
 - Provide additional training to staff to take into account the needs of the older adults and people with disabilities.
 - Operate demand-response services for the general public or support local communities that provide demand-response services.
 - Coordinate and encourage local community bus services or support local communities that operate more neighborhood-oriented bus services through public-private partnerships.
 - Improve “run-cutting” (matching runs and shifts to demand).

- Use non-dedicated service providers to supplement dedicated runs.
- Use computer-aided dispatch (CAD) combined with an automatic vehicle location (AVL) system to coordinate passenger trips and transfers. Transmit vehicle locations in real-time so that they are available for the traveling public.
- Employ one-call, one-click transportation centers that provide real-time information and assistance to people that have difficulty planning and getting to essential services.
- Consider offering transportation alternatives such as the use of telemedicine to reduce transportation requirements.

- **Rail Vehicles**
 - Provide level boarding for wheelchairs and others with walking disabilities.
 - Design railcars with adequate passage widths, space for wheelchairs, priority seating near entrances/exits and handrails and step edges.
 - Display train stops on the side of the train along with audio announcements of the train line.
 - Announce train stops and display stops inside the rail cars.

- **Bus Stops**
 - Place bus stops close to amenities with paved, level surfaces and ample space for passengers to avoid obstructing pedestrian walkways.
 - Extend bus bulbs to the edge of the traffic lane and provide additional space to allow for passengers to board buses closer to the curb.
 - Shelters and benches should be accessible, making space for wheelchairs and other aids to maneuver. Include wheelchair ramps, transit stop/station announcements at major or requested stops, designated seating near the front door, large-print signage, and the ability of the bus to kneel or lower for boarding ease on all fixed-route transit system vehicles.
 - Use raised roadside structures as an alternative to low-floor buses or buses with mechanical lifts.

- **Bus and Train Stations**
 - Entrances should be fully accessible on at least one side.
 - Ramps are usually the best way to provide wheelchair access between different floor levels.
 - Steps and stairs should have handrails on both sides.
 - Provide signage throughout the stations, particularly for the hearing impaired. Ensure that wayfinding techniques are incorporated within the transportation system. Wayfinding cues include signs and maps, marked pathways, landmarks, and lighting.
 - Information should be clearly identifiable and simple to understand.

Webinars

A webinar, by definition, is an online seminar where participants can share screens and visualize the same content. A key feature of a webinar is the ability for interaction between the facilitator and participants through online tools that permit the sharing and discussing of information in real-time

across a large group of geographically diverse participants in a structured setting.²² The goal of the webinars in this project was to gain input from people with disabilities, Veterans with disabilities, and older adults (including their caregivers and advocates) regarding their specific transportation needs and mobility challenges. Another objective of the webinars was to engage these same participants in a dialogue to obtain information on how technologies may address their needs and/or overcome their barriers to transportation.

Webinar Methodology

Three (3) different webinars were conducted for this project, all using the same general methodology. Each webinar began with an overview of ATTRI and the purpose and goals of the webinar, and then focused on one of the three target populations and covered all of the aforementioned four types of disabilities. A guest speaker provided personal experiences and updates on programs or projects directed toward the area specific to the target population of the webinar in order to engage the participants in meaningful dialogues. The facilitator then walked participants through a hypothetical typical trip, and participants provided feedback on user needs and barriers for each trip segment. Finally, each webinar ended with real-time evaluations of the webinar, and questions were answered in a discussion session, as time permitted.

Invitations were sent out to the targeted populations for each of the three (3) ATTRI webinars.²³ Participants' responses and comments were captured through polls and chat boxes, and then categorized and grouped to provide meaningful results. Over 700 individuals registered for the three webinar series, and nearly 600 participants attended the webinars. U.S. DOT conducted these webinars between March 3, 2015 and April 14, 2015, with support from Battelle, Texas A&M Transportation Institute (TTI), and the Open Doors Organization (ODO).²⁴ The first two webinars were hosted by Ms. Charlene Wilder (FTA) and Mr. Mohammed Yousuf (FHWA), and the third was hosted by Ms. Charlene Wilder (FTA) and Mr. Rik Opstelten (FTA). Mr. Eric Lipp (ODO) facilitated discussions in all three webinars.

Guest Speaker Presentations

Webinar 1, *ATTRI Stakeholder Engagement and User Needs for People with Disabilities*, was held on March 3, 2015. During this webinar, Mr. Jamal Mazrui²⁵ discussed his role at the Federal Communications Commission (FCC) in promoting a cross-sector collaborative program solving accessibility issues of modern communication technologies and how ATTRI's effort can improve transportation accessibility. Mr. Mazrui discussed his user needs from the perspective of a technology developer and policy analyst who is blind; including an example of a recent trip he took to a conference involving multiple modes of transportation.

Webinar 2, *ATTRI Stakeholder Engagement and User Needs for Older Adults*, was held on March 24, 2015. During this webinar, Dr. Mary Leary discussed her role at FTA as the Division Chief for Rural and Targeted Programs. This division oversees specialized formula and discretionary transportation grants including Section 5310 *Enhanced Mobility for Seniors and People with Disabilities*. These grants provide a rich possibility for emerging technology. Dr. Leary also discussed functional changes

²² <http://www.webopedia.com/TERM/W/Webinar.html>

²³ Online recordings of the webinars can be found at: http://www.its.dot.gov/attri/attri_user_webinar.htm

²⁴ Recordings of the webinars and updates on the ATTRI Program can be found at http://www.its.dot.gov/attri/attri_user_webinar.htm

²⁵ Deputy Director, Accessibility and Innovation Initiative, FCC Chairman's Award for Advancement in Accessibility <http://www.fcc.gov/document/advancement-accessibility-awards-nominations>.

related to aging and how people are affected differently, such as, the need to take a person-directed approach to providing assistance. She discussed how accessibility technology needs to address all aspects of mobility, including highway signage, types of public transit options including escorts/paratransit, and easy access to information for planning a trip.

Webinar 3, *ATTRI Stakeholder Engagement and User Needs for Veterans with Disabilities and Wounded Warriors*, was held on April 14, 2015 and included two guest speakers. Mr. Ed Straub, the first speaker, discussed Applied Robotics for Installation and Base Operations (ARIBO) while familiarizing users and non-users with automated vehicle systems. ARIBO is a different approach to technology transition. It coordinates efforts and investments to accelerate fielding automated technologies. It provides the opportunity to align objectives across government agencies and affordably leverage Federal investments in automated ground systems (e.g. U.S.DOT, NASA, DOE, VA, etc.²⁶) for common goals. Stakeholder involvement, identification of the problem/business case, and the challenges that must be overcome are important to ensure user and non-user acceptance. Mr. Paul Perry, the second presenter, discussed transportation challenges faced by Veterans, the business case for mobility management, and improving access to care. User needs and barriers discussed by Mr. Perry included: access to VA medical services; difficulties coordinating with existing community and public transportation services; long wait times; the need to schedule appointments; challenges in rural areas; and difficulties communicating Veterans' needs to community transportation services.

Hypothetical Trip(s)

During each webinar, the facilitator walked participants through a hypothetical typical trip using a five trip segments model (shown in Figure 2-2) and asked questions regarding user needs and barriers. In particular, participants of each webinar answered questions such as “Describe your needs for reliable, safe, and independent transportation” and “Describe barriers to reliable, safe, independent travel” during each trip segment (trip planning, departure, en-route, arrival, and return).



Source: U.S. DOT/Thinkstock/TTI

Figure 2-2. Five Trip Segments used in the Webinars for a Typical Hypothetical Trip

These trip segments were used to show existing or emerging technologies and to help participants visualize technologies that could remove barriers to achieve reliable, safe, and independent travel. During the hypothetical trip planning exercise, the participants provided feedback on user needs and

²⁶ National Aeronautics and Space Administration (NASA), U.S. Department of Energy (DOE), U.S. Veterans Administration (VA).

barriers for each trip segment respective to the target population, and recommended technologies and solutions that could facilitate their travel experience with minimal/reduced disruption.

The **Trip Planning** segment includes information regarding the origin and destination of a person's trip, as well as the variables that would contribute to the decision-making process such as the mode, location of the transit stop, desired/acceptable duration of the trip, proximity of the station at the arrival location, quality of the trip, overall scheduling, etc. Several questions that are addressed during the trip planning segment included:

- Where am I going?
- How am I getting there? What is the best mode of transportation to take?
- When do I need to depart? When do I arrive?
- When is the next service if I miss my connection?
- What are the environmental conditions (such as lighting, safety, etc.)?
- Are there any scheduled closure/detour conditions due to construction and maintenance activities?

Departure is the segment where the person is at the front door or 'origin' of the trip, immediately prior to the en-route segment of the trip, and addresses questions associated with the immediate departure concerns such as:

- When will my ride arrive?
- Does my car have fuel?
- What are the pathway conditions? Are the pathways clear?
- Do I have directions to my destination?

The **En-route** segment covers the information and decision-making that occurs while a person is taking the trip (walking, biking, or aboard a transit (or paratransit) vehicle). There are expected challenges that occur during the trip's en-route segment and, based on the proper pre-trip planning activity in the trip planning segment, the travelers should be equipped with information regarding these challenges to avoid, minimize, or mitigate such challenges. Despite this, unforeseen activities may interfere with a planned trip such as weather conditions, non-recurring events such as incidents, including unplanned/unscheduled emergency maintenance/construction along the route, etc. Therefore, the en-route segment is critical in the sense that it involves dynamic activity and decision-making processes that could be influenced by factors outside of the person's control. Because the trip is already initiated, any unplanned/unexpected changes could have significant impact on the rest of the trip's schedule, connections, and/or completion of the trip. Some of the questions during the en-route segment included:

- Am I lost?
- I forgot which stop to exit, whom can I ask for help?
- What do I do if I am late or miss my connection?
- When is the next service if the bus/train/subway is running late and I miss my connection?
- What if the transit vehicle has to take a detour due to unexpected activity (i.e., weather, incident, etc.?)

The **Arrival** segment is when the en-route segment is concluded and the person arrives at his/her destination (public facility or station). At this segment of the trip, navigational and environmental questions, as well as schedule, connection, safety, and security types of questions/concerns are of interest, especially if the destination is not a familiar/regular arrival point for the person. Some of these questions included:

- How do I find my way around to the exit (station), sidewalk/curb ramp, or my destination (building, venue, etc.)?
- Is there a place to sit?
- Is there a restroom at the station?
- Is the elevator working?
- Is there a shelter?
- Is it safe to wait here? Is the area well lit?
- When is the next transit vehicle coming?

The **Return** segment of the trip is very similar to the sequence of the arrival trip, except the direction of the trip is reversed.

Technology Access and Issues

In addition to questions regarding their travel needs and barriers to their travel, webinar participants were also specifically asked to provide information regarding access and availability of technology options. These questions included asking participants “What technologies do you have access to at home?” and “What issues might you have with new technology?” The purpose of these questions was to gather specific information on whether participants perceived technologies as solutions, needs, or barriers to their travel.

Summary of Data Collected During Webinars

Each webinar provided a wealth of information from the nearly 600 participants who were fairly evenly divided among three webinars and targeted populations of interest. One significant challenge of the webinar facilitator was to capture and compile the diversity of responses and information provided by the participants. Generally, however, the participant responses from the three webinars clearly demonstrate that people with disabilities, Veterans with disabilities, and older adults face significant transportation barriers. Access to adequate transportation enhances the quality of life for everyone, but specifically allows individuals with mobility needs to fully participate in society and community activities. In all three webinars, participants indicated that information, options, assistance, and access were, in descending order of importance, the greatest needs to reliable, safe, and independent travel. Participants also indicated that the greatest barriers to reliable, safe, and independent travel were inadequate transportation options and amenities; lack of technology access, inadequate infrastructure, signage, or wayfinding tools; and lack of travel support/customer service, in descending order of importance.

Identified User Needs among Webinar Participants

Participants responded to the statement “Describe your needs for reliable, safe, and independent transportation (during each trip segment).” They provided 1,203 responses that were compiled into 27

unique types of needs and further classified into the four categories: Information, Options, Access, and Assistance briefly described below (see **Error! Reference source not found.**).

Information – The availability, format, accuracy, and accessibility of the information are very critical in order to accommodate convenient, safe, and accessible transportation across all modes. In most cases, the availability and quality (i.e. comprehensiveness, comprehensibility, and accuracy) of information are not only crucial for travelers with disabilities, but also critical for daily commuters or visitors without mobility constraints. In addition to availability and quality, information also covers a wide range of areas from personal/personalized information to emergency procedures to inform the broader audience. The following are the general subcategories where similar information types are clustered for the purposes of the ATTRI evaluations:

- Amenity/Facility (restroom, shelter, bench, food, beverage, platform, elevator, escalator, information desk, etc.)
- Schedule/Trip (real-time information, transit schedule, connections, transfers, trip distance, trip duration, interagency coordination, modal schedules, en-route information, etc.)
- Wayfinding (guidance signage, destination information, addresses, layout, street connections, entrance/exit locations, locations of elevators and escalators, station and area mapping, directions to key amenities and points of interest, landmarks, orientation, etc.)
- Environmental Conditions (roadway conditions, real-time construction/closure, physical obstacles, weather conditions, pathway connectivity such as sidewalks, street connections, linear and continuous pathways, etc.)
- Accessibility (information on various accessibility formats along a transit route or mode, somewhat similar to “metadata” concept)
- Emergency (safety, security, emergency communication options, lighting conditions, etc.)
- Personal (personal list of medical needs, emergency contacts, medical equipment needs, standardized profile of the traveler, instructions about procedures for medical emergencies, etc.)

Options – The needs/barriers classified under this category include elements that would enhance the traveler’s experience and increase the probability of an uninterrupted trip. These elements include payment options for people with disabilities that would eliminate/minimize the need for having to understand different fare structures and paying with exact change, simplified fare information, accessibility information about the vehicles on a specific route or at a specific time, charging stations for battery dependent devices such as tablet computers, smart phones, etc., and options for the “first/last mile” connections. Although not necessarily “essential” to complete a trip, some elements such as charging stations could have a crucial impact on the travelers’ ability to complete their trip. For example, if the person is dependent on the routing/scheduling information saved on their smartphone or portable computer device, he or she would not be able to access that information during their trip if the battery of his or her device is drained and there are no charging stations available at the facilities along the route.

Assistance – This category includes assistance during the trip planning stages such as availability of accessible customer service or help line, or assistance during the trip, such as a trained transit staff to provide assistance for personal mobility and travel, or other assistance from the transit operators. For example, some persons with disabilities may require additional assistance to board a transit vehicle

that could include providing support for balance, working the locking mechanism to secure wheelchairs for movement, or assistance with luggage. Within the context of ATTRI evaluations, the assistance category includes assistance provided by the transit and/or transportation agencies, rather than personal and/or medical assistance.

Access – This category is mainly concerned with the accessibility of the transit facilities rather than the transit vehicles. Interest areas under the access category include connectivity of the transit routes, intermodal connectivity, continuous pathways and walkways, linear pathways that eliminate/minimize roadway crossing, connectivity of the pathways such as accessible ramps at the intersections, and accessibility of parking facilities and transit facilities such as the platforms, station buildings, etc. Availability of such features is desirable; however, as discussed under the ‘information’ category, availability of information about these features is equally important to ensure such features serve a functional purpose.

Table 2-1. User Needs Reported by Number of Webinar Participants

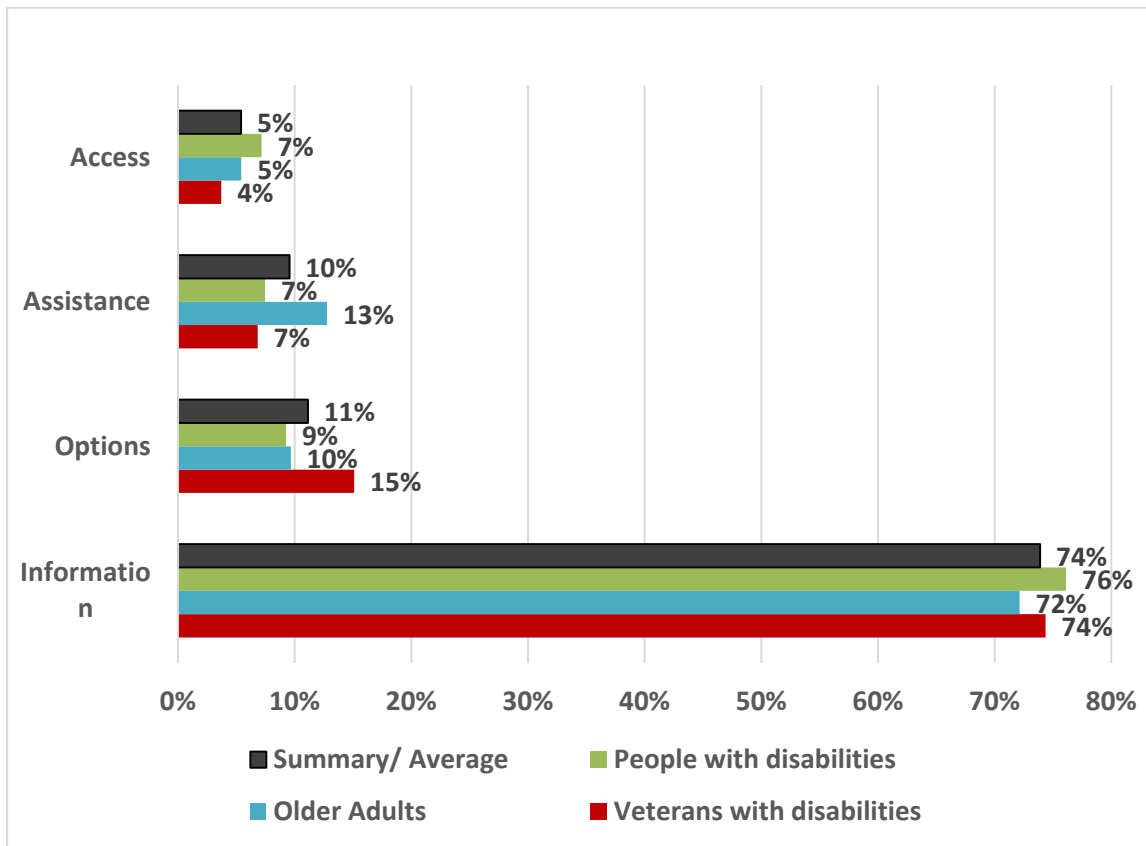
Category	User Need	W1^a	W2^b	W3^c	Total
Information	Amenity information (e.g. restroom, shelter, benches, food, drinks)	28 (8%)	43 (8%)	31 (9%)	102 (8%)
	Real-time transportation information	32 (10%)	37 (7%)	19 (5%)	88 (7%)
	Safety, security and emergency information	22 (7%)	34 (7%)	20 (6%)	76 (6%)
	Transit schedule and other transit information	10 (3%)	28 (5%)	22 (6%)	60 (5%)
	Destination information (hours, addresses, entrances, layout)	16 (5%)	19 (4%)	23 (7%)	58 (5%)
	Mapping/directions	8 (2%)	36 (7%)	11 (3%)	55 (5%)
	Roadway/pathway real-time conditions	26 (8%)	14 (3%)	15 (4%)	55 (5%)
	Information in variety of accessible formats	20 (6%)	21 (4%)	11 (3%)	52 (4%)
	Connection information (where, who, when)	17 (5%)	16 (3%)	17 (5%)	50 (4%)
	Weather conditions	13 (4%)	16 (3%)	17 (5%)	46 (4%)
	En-route assistance and information	17 (5%)	17 (3%)	12 (3%)	46 (4%)
	Trip length/distance	7 (2%)	21 (4%)	16 (5%)	44 (4%)
	Signage	4 (1%)	27 (5%)	11 (3%)	42 (3%)
	Transportation facility information	14 (4%)	6 (1%)	9 (3%)	29 (2%)
	Personal list of travel needs (e.g. oxygen, emergency #)	5 (1%)	12 (2%)	11 (3%)	28 (2%)
	Coordination information (between agencies, modes)	7 (2%)	13 (3%)	7 (2%)	27 (2%)
	Profile of traveler (for agency to accommodate traveler)	3 (1%)	7 (1%)	8 (2%)	18 (1%)
Landmarks and orientation identifiers	6 (2%)	6 (1%)	1 (0%)	13 (1%)	
Options	Accessible payment options and trip cost information	7 (2%)	13 (3%)	24 (7%)	44 (4%)
	Flexible and/or spontaneous travel options	9 (3%)	9 (2%)	16 (5%)	34 (3%)
	Vehicles with accessible equipment	9 (3%)	10 (2%)	5 (1%)	24 (2%)
	Technology, communications devices and recharging for traveler use	4 (1%)	13 (3%)	6 (2%)	23 (2%)
	“Last mile” transportation options	2 (1%)	5 (1%)	2 (1%)	9 (1%)
Assistance	Traveler help line/customer service	11 (3%)	37 (7%)	13 (4%)	61 (5%)
	Personal care attendant or other assistive/training services	14 (4%)	29 (6%)	11 (3%)	54 (4%)
Access	Connected, continuous, accessible pathways	23 (7%)	27 (5%)	11 (3%)	61 (5%)
	Accessible parking locations and availability	1 (0%)	1 (0%)	2 (1%)	4 (0%)
Totals		335 (100%)	517 (100%)	351 (100%)	1,203 (100%)

- a. Webinar 1 was focused on Persons with Disabilities
- b. Webinar 2 was focused on Older Adults
- c. Webinar 3 was focused on Veterans with Disabilities

Source: Battelle/TTI

U.S. Department of Transportation, Office of the Assistant Secretary for Research and Technology
Intelligent Transportation Systems Joint Program Office

By categorizing participants' responses, the distinction between the four (4) main types of needs became clear with Information needs being cited by participants as their predominant need (74 percent of all provided needs) followed by Options, Assistance, and Access with 11 percent, 10 percent, and 5 percent of the needs, respectively. These percentages were fairly consistent across the three sub-segments of the population as illustrated in Figure 2-3. Within the Information category, information on “amenities” was cited most frequently by webinar participants followed closely by “real-time transportation information” and “safety, security, and emergency information.” Users also expressed the need for a traveler helpline or customer service; needs that were grouped into the Assistance category. Accessible payment options and trip cost information were conveyed as user needs, and were grouped into the Options category. Connected, continuous, and accessible pathways were also conveyed as user needs and are contained within the Access category.



Source: Battelle/TTI

Figure 2-3. Categorized User Needs Reported by Webinar Participants

User Barriers Identified by Webinar Participants

Similar to the identification of user needs, identification of the barriers involved asking the participants to define and describe those barriers encountered during each segment of a trip (pre-trip planning, departure, en-route, arrival, and return). The major difference in the assessment of the user needs and barriers is that the needs tended to be derivatives of a person’s capabilities, expectations, personal schedule, etc., that are generally within the control of the person and can be classified as “user-defined.” On the other hand, the potential cause of barriers was a function of internal, external, and natural factors that are, contextually, within the realm of the transportation and transit agencies. In

total, the webinar participants provided 965 responses on barriers that they encounter (see Table 2-2).

Table 2-2. Barriers Identified by Webinar Participants

Barrier Category	Barrier Type	W1 ^a	W2 ^b	W3 ^c	Total
Adverse perception of travel	Heavy crowds and noise	3 (1%)	9 (3%)	8 (3%)	20 (7%)
	Perceived or real safety or cleanliness	5 (2%)	20 (7%)	5 (2%)	30 (10%)
	Weather	14 (5%)	20 (7%)	20 (7%)	54 (19%)
Cost	High cost or lack of resources/funds	6 (2%)	15 (5%)	20 (7%)	41 (14%)
Inadequate infrastructure, signage, or wayfinding tools	Inadequate crosswalk infrastructure or signal times	4 (1%)	8 (3%)	2 (1%)	14 (5%)
	Inconsistent accessible pathway infrastructure	20 (7%)	29 (10%)	18 (6%)	67 (23%)
	Lack or inaccessible signage/maps/landmark identifiers/announcements	28 (10%)	34 (12%)	13 (5%)	75 (26%)
Inadequate transportation options and amenities	Lack of accessible service, facility information (or not current)	17 (6%)	18 (6%)	23 (8%)	58 (20%)
	Lack of available transportation (limited hours, vehicles, service area, etc.)	17 (6%)	19 (7%)	21 (7%)	57 (20%)
	Lack of first mile last mile options	3 (1%)	6 (2%)	5 (2%)	14 (5%)
	Limited or no accessible amenities (restrooms, benches, shelter, water fountains)	16 (6%)	20 (7%)	13 (5%)	49 (17%)
	Non-flexible transportation options (no same day service, same day changes)	4 (1%)	18 (6%)	8 (3%)	30 (10%)
	Trip lengths/duration too long	8 (3%)	14 (5%)	19 (7%)	41 (14%)
	Unreliable transportation (fleet, equipment, on-time performance)	24 (8%)	15 (5%)	9 (3%)	48 (17%)
	Vehicle/facility configuration or policy does not meet need	15 (5%)	16 (6%)	6 (2%)	37 (13%)
Lack of technology access	Lack of access to technology (phones, computers, charging--or lack of training)	15 (5%)	17 (6%)	8 (3%)	40 (14%)
	Lack of real-time travel information	20 (7%)	12 (4%)	15 (5%)	47 (16%)
	Navigation difficulties (do not know when arrive, transfer time, distance)	19 (7%)	30 (10%)	22 (8%)	71 (25%)
Lack of travel support/ customer service	Lack of assistance or attendants	9 (3%)	21 (7%)	10 (3%)	40 (14%)
	Lack of coordination/comprehensive travel information	6 (2%)	8 (3%)	11 (4%)	25 (9%)

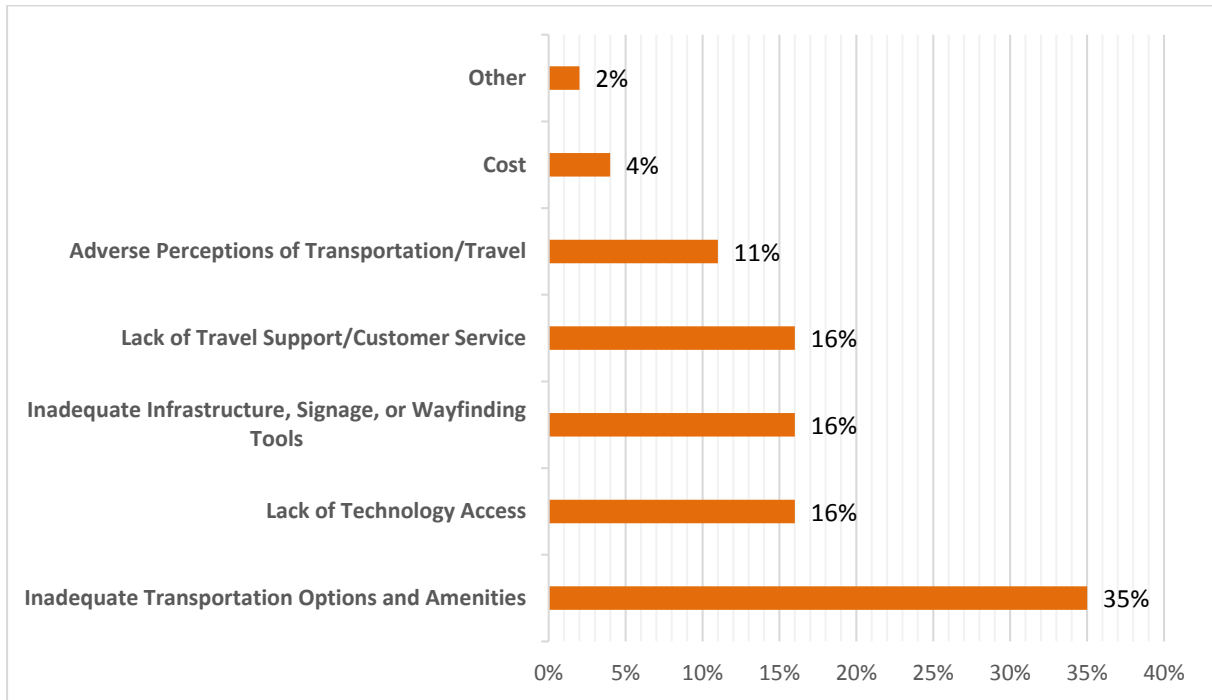
U.S. Department of Transportation, Office of the Assistant Secretary for Research and Technology
Intelligent Transportation Systems Joint Program Office

Barrier Category	Barrier Type	W1 ^a	W2 ^b	W3 ^c	Total
	Lack of customer service or helpline	8 (3%)	17 (6%)	9 (3%)	34 (12%)
	Lack of destination or transfer information (who, what, where)	12 (4%)	10 (3%)	13 (5%)	35 (12%)
	Language/communication	13 (5%)	7 (2%)	1 (0%)	21 (7%)
Other	Driving barriers (lack of parking, cannot navigate heavy traffic)	1 (0%)	10 (3%)	6 (2%)	17 (6%)
Totals		287 (100%)	393 (100%)	285 (100%)	965 (100%)

- a. Webinar 1 was focused on Persons with Disabilities
- b. Webinar 2 was focused on Older Adults
- c. Webinar 3 was focused on Veterans with Disabilities

Source: Battelle/TTI

Across all of the webinar participants responses, “inadequate options and amenities” were cited as the greatest barrier to reliable, safe and independent travel. However, when the responses from the older adults were evaluated, the next three greatest barriers were identified as inadequate infrastructure, signage, or wayfinding tools; lack of travel support/customer service; and lack of technology access. For Veterans with disabilities, the next three greatest barriers were identified as “lack of technology access; lack of travel support/customer service; and inadequate infrastructure, signage, or wayfinding tools.”

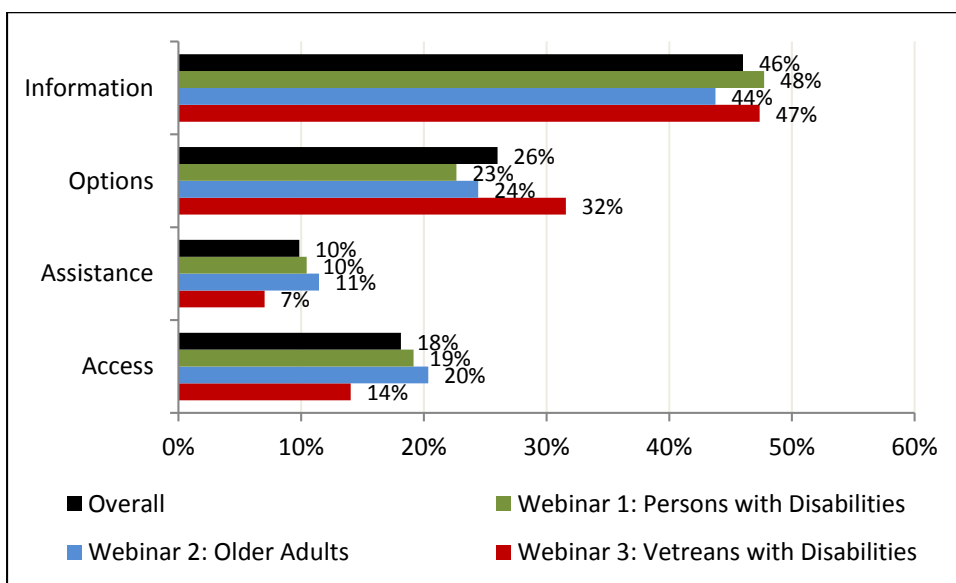


Source: Battelle/TTI

Figure 2-4. Summary of Barriers Identified by Webinar Participants

The same types of barriers presented in could also be categorized by the same four categories that user needs were focused on: Information, Options, Access, and Assistance (see Figure 2-5). Not surprisingly, given the state of user needs by webinar participants, the predominant barrier types reported by webinar participants were concentrated around the information category. It was also noted that the barriers clustered under the information category also tended to be those barriers that are “internally” focused factors rather than “natural” or “externally” focused factors.

Internal factors are those that group the barriers for which prevention, avoidance, minimization, or mitigation would rest within the transit or transportation agencies’ realm. The agency would be expected to have direct control over addressing such barriers within its internal decision-making process and authority. Natural factors include those for which the cause is a natural event, such as recurring and non-recurring weather events. Prevention of such factors are obviously outside of an agency’s realm; however, mitigation of the subsequent conditions, such as snow build-up along paths to transit stops and stations, proper drainage at transit stops, restoring the visibility of electronic signage after a snow storm, etc. are within the transit or transportation agencies’ maintenance responsibilities. Finally, external factors are barriers for which the underlying factors are elements that are influenced by the decisions of the regional planning agencies. These factors include variables such as headways and schedules based on the demand, service area, etc. Such factors typically function as proxies for larger issues that affect planning, such as population and employment density, capital improvement programs (CIPs), Transportation Improvement Programs (TIPs), and Statewide Transportation Improvement Programs (STIPs). External factors also include planning and deployment efforts that would require collaboration and consensus of transportation and transit agencies in the area, regional agencies such as Metropolitan Planning Agencies (MPOs), as well as other interest groups. Standardization of accessibility features and technologies, integration of data among multiple agencies, etc. are examples of such efforts that would require regional collaboration.



Source: Battelle/TTI

Figure 2-5. Summary of Barriers Reported by Webinar Participants By Category

Within the predominant Information-related barrier category, “lack or inaccessible signage/maps/ landmark identifiers/announcements,” “navigation difficulties,” and “lack of (or not current) accessible service, facility information” were the predominant barrier types identified by webinar participants.

These three predominant barriers are also within the internal factor cluster. In fact, all of the barrier types grouped under the Information category are barriers associated with ‘internal’ factors; thus, addressing these barriers could be addressed by transportation/transit agencies.

The three predominant barrier types under the Access category were “inconsistent accessible pathway infrastructure,” “lack of access to technology (phones, computers, charging—or lack of training),” and “vehicle/facility configuration or policy does not meet need.” Similar to the barriers in the Information category, these barriers are in the internal factors cluster, which indicates that the solutions to mitigate them can be addressed by transportation/transit agencies.

The underlying elements for the majority of the barriers under the Options category were also noted to be external factors, because they fall outside of the transportation/transit agencies’ realm, such as the provision of service to cover certain geographic areas, increased service frequency, etc.

Unsurprisingly, the two barriers under the Assistance category were attributable to internal factors, because they are associated with an agency’s internal decisions/policies to provide quality customer service and staff training to assist travelers with disabilities.

Identified Technology Access and Issues

A total of 275 participants responded to the questions “What technologies do you have access to at home?” and “What issues might you have with new technology?” It should be noted that the participants could choose more than one technology that was available to them. Based on the participants’ responses, Table 2-3 provides the distribution of technologies available to the respondents by webinar. These responses show that 62 percent of participants have access to technology by means of a computer, 52 percent by a smartphone, and 33 percent by a tablet.

Table 2-3. Distribution of Technologies Available to Respondents²⁷

Available Technology Type	Webinar 1 – People with Disabilities	Webinar 2 – Older Adults	Webinar 3 – Veterans with Disabilities	Total
Computer/Internet	54 (50%)	72 (65%)	45 (82%)	171 (62%)
Smart Phone	46 (42%)	53 (48%)	45 (82%)	144 (52%)
Cell Phone (No Internet)	41 (38%)	40 (36%)	38 (69%)	119 (43%)
Landline	46 (42%)	65 (59%)	45 (82%)	156 (57%)
Tablet	27 (25%)	39 (35%)	24 (44%)	90 (33%)
Cable/Satellite	41 (38%)	68 (61%)	29 (53%)	138 (50%)
Other	0 (0%)	7 (6%)	4 (7%)	11(4%)
Total Number of Webinar Participants	109	111	55	275

Source: Battelle/TTI

Table 2-4 provides the number and percentage (in parenthesis) of participant responses corresponding to a specific technology issue, and the responses are organized by each webinar. The

²⁷ Not mutually exclusive (i.e., the sum of percentages for the technology or webinar does not equal to 100%, because the participants could choose more than one technology that is available to them.)

'training to use and the awareness of technology' issue was ranked as the most significant by participants of all three webinars. Attendees of the Older Adults and Veterans with Disabilities webinars prioritized technology issues exactly the same. While the attendees of the webinar for People with Disabilities ranked 'affordability' as the issue with lowest priority, attendees of the Older Adults and Veterans with Disabilities webinars ranked 'affordability' as the second highest priority issue with new technology. For those attending the webinar for People with Disabilities, 'performance quality' was the second highest issue.

Table 2-4. Technology Issue Categories

Technology Issue	Webinar 1 – People with Disabilities	Webinar 2 – Older Adults	Webinar 3 – Veterans with Disabilities	Total
Training to use and awareness of new technology	43 (39.5%)	61 (55%)	20 (36%)	124 (46%)
Affordability	11 (10%)	30 (27%)	17 (31%)	58 (21%)
Performance quality (especially long-distance travel/ rural areas)	24 (22%)	11 (10%)	10 (18%)	45 (16%)
Accessibility to all disability types	19 (17.5%)	0 (0%)	0 (0%)	19 (7%)
Integration and compatibility to existing technology	0 (0%)	6 (5%)	6 (11%)	12 (4%)
Maintenance	12 (11%)	0 (0%)	0 (0%)	12 (4%)
Concern of confidentiality and theft	0 (0%)	3 (3%)	2 (4%)	5 (2%)
Total	109 (100%)	111 (100%)	55 (100%)	275 (100%)

Source: Battelle/TTI

ATTRI In-Person Workshop

Conceptually, a workshop is very similar in nature to a webinar where there is an information exchange between participants. However, a workshop offers the potential for a more in-depth and focused discussion among participants than does a webinar. In this project, a workshop was convened with the primary goal of obtaining feedback on how emerging technologies may address the identified needs and barriers of people with disabilities, Veterans with disabilities, and older adults in order to provide better travel solutions. The secondary goal was to validate the results of the webinar series that were previously conducted.

Participants in the workshops and Listening Sessions at Conferences represented all three sub-populations of interest; persons with disabilities, older adults, and Veterans with disabilities. Attendance at each of the Listening Sessions was significantly lower than at the in-person workshop, but the methodologies and information collected were similar.

In-Person Workshop Methodology

The ATTRI Stakeholder Engagement and User Needs Workshop was held on April 30, 2015 between 8:30 a.m. and 4:30 p.m. EST at the Mayflower Renaissance Hotel in Washington, DC. Dr. Mary Leary, the Division Chief of Rural and Targeted Programs for FTA, was the facilitator of the workshop. Dr. Leary outlined the strategy of the workshop for participants, kept the workshop on track, and engaged the participants in focused discussions about the technology areas being researched by the ATTRI program.

Opening remarks were presented by the following U.S. DOT representatives:

- Dr. Bryna Helfer, *Deputy Assistant Secretary for Public Engagement*, Office of the Secretary of Transportation, U.S. DOT
 - Topic: Where we are and where we are headed?
- Dr. Joe Peters, *Director*, FHWA Office of Operations Research and Development
 - Topic: The promise of emerging technologies to enable transportation solutions
- Ms. Linda Ford, *Director*, FTA Office of Civil Rights
 - Topic: Assuring equal access for all to public transportation
- Ms. Nichole McWhorter, *Division Manager*, Coordination and Compliance Division, FHWA Office of Civil Rights
 - Topic: How ATTRI will enhance the social and economic quality of life for all Americans

Following a discussion period focused upon these opening remarks and presentations, the workshop participants were briefed on the ATTRI program by Mr. Mohammed Yousuf, ATTRI Program Manager at FHWA. Mr. Yousuf emphasized the multimodal nature of the ATTRI program, multi-agency research and development efforts underway, and various partnerships undertaken by the research program. His presentation focused on how ATTRI is addressing the challenges faced by people with disabilities in accessing transportation, as well as the desire to extend the benefits gained from the ATTRI program to all travelers. He discussed the opportunities to find synergies and create convergence with other existing technologies that have not traditionally been used for transportation.

After this initial ATTRI briefing, Mr. Eric Lipp from Open Doors Organization and Ms. Suzie Edrington of TTI presented an overview of the user needs and barriers from the findings/results of the previous ATTRI webinar series. Mr. Lipp focused on the challenges facing people with disabilities, older adults, and Veterans with disabilities/wounded warriors. Ms. Edrington discussed the results of the ATTRI webinars, including the goals and objectives, and continued to present a summary of the technology issues and their distribution based on the participant responses, and the identified user needs and barriers based on the responses during the three previous ATTRI webinars.

At the conclusion of these presentations, workshop participants were self-divided into three of five breakout sessions to allow for smaller group discussions regarding the respective technologies, and map the technology areas to user needs. Workshop participants chose to attend three of the following technology area sessions:

- Wayfinding and Navigation
- Intelligent Transportation Systems (ITS) and Assistive Technologies
- Automation and Robotics
- Data Integration
- Enhance Human Services Transportation.

Each breakout session began by orienting participants with the workbook and presenting a brief overview of the technology area, along with the potential benefits of the technology. Next, hypothetical transportation and access scenarios were presented and discussed based on the four functional disability categories (vision, mobility, hearing, and cognitive). Participants were asked to record their thoughts and key discussion points in the workbook. Figure 2-6 provides an illustration of the workbook data collection form.

After each scenario was presented, the participants discussed how the technology addressed the identified needs for each of the four functional disability types (vision, hearing, cognitive, and mobility), and which of the following travel purposes is expected to benefit most from this technology solution:

- Education/training
- Jobs/employment
- Medical
- Recreation/leisure
- Shopping
- Other.

Participants' responses were captured and collected on flipcharts, data sheets, and meeting minutes. Facilitators for each breakout session were provided to guide the discussions and record information provided by the workshop participants.

Source: Battelle/TTI

Figure 2-6. Illustration of Workshop Workbook Data Collection Form

Summary of Data Collected from In-Person Workshop Participants

The opening remarks generated candid discussions, where the topics ranged from affordability and accessibility of the technology to infrastructure planning, connectivity, and interoperability. Concerns were raised about the accessibility of newer transportation options or ridesharing services such as, Uber™ and Lyft™. In addition, suggestions were made such as leveraging existing military research and developmental technologies and applying them to public transit. Policy related discussions centered on topics such as the need for stronger Americans with Disabilities Act (ADA) policies, resources for finding more information about ADA policies and policy-making process, and potential mechanisms/methods to become more involved to influence policies during the policy-making process.

The information gathered from participants regarding traveler needs and barriers during the “Listening Sessions” at conferences was consistent with the information gathered during the Literature Review and Webinars regarding user needs and barriers to mobility. Participants voiced concerns of new technology creating an overload of information. They also expressed concern that there is a lack of public transit in rural areas and that ridesharing services are not ADA compliant. In addition, conference participants noted that existing ADA regulations are not enforced. Discussions and comments from workshop participants regarding the ATTRI briefing and the user needs and barriers that were identified during the literature review, webinars, and Listening Sessions validated those findings. This can be clearly seen by comparing the discussion points from the breakout sessions to the user needs and barriers identified during the literature review and webinars.

The following summarizes the data and discussions between workshop participants for each of the five breakout sessions. A summary of the findings and the conclusions of the data collected is presented in subsequent chapters in this report.

Wayfinding and Navigation

Approximately 33 participants attended the three (3) Wayfinding and Navigation technology area sessions. This technology area consists of exploration and development of situational awareness and assistive navigation solutions. The majority of workshop participants indicated that spontaneous travel, recreation, and leisure are the travel purposes most impacted by Wayfinding and Navigation traveler needs, and travel training also emerged as important topics for Wayfinding and Navigation solutions. Wayfinding and Navigation solutions need to be able to address a broad continuum of traveler needs. Table 2-5 summarizes the discussions and overall thrust of the conversations by workshop Wayfinding and Navigation Breakout participants as they relate to the types of disabilities.

Intelligent Transportation Systems (ITS) and Assistive Technologies

The majority of workshop participants indicated that jobs and employment are the travel purposes most impacted by ITS and Assistive Technologies. This was closely followed by all purposes of travel being impacted. Traveler communication emerged as an important topic for ITS and Assistive Technologies. Table 2-6 summarizes the discussions and overall thrust of the conversations by workshop ITS and Assistive Technology Breakout participants as they relate to the types of disabilities.

Table 2-5. Discussion Points from the Wayfinding and Navigation Breakout Sessions

Type of Disability	Summary of Discussion Points
Vision	<ul style="list-style-type: none"> • “Talking signs” and audible information about fixed objects can assist in trip planning. • Existing applications can be used as the starting point for applications that can assist travelers who are blind or have low vision. • The ability for a traveler to navigate indoors is as important as outdoors. • Mobility and travel training is needed to orient travelers with disabilities to fixed route service and to cope with changes in the environment. • Guide dogs remember how to get to and go from places. A virtual guide dog could provide indoor and outdoor navigation. • Technology that would allow travelers to input their station or stop onto their smartphone or other similar device, then alert the passenger (and/or driver) by signaling (e.g., buzzing) at the appropriate time to disembark/exit at the designated transit stop. • Google Earth™ could be integrated with the transit agency data to let travelers know where the closest transit stops are located. • “Low technology” solutions and options need to also be considered in conjunction with “high technology” solutions.
Hearing	<ul style="list-style-type: none"> • Dynamic mapping and navigation can provide visual maps locating the traveler’s current location and what is going on nearby. • A device that translates speech to text would be helpful for not only receiving station announcements, but also assist in communicating with drivers, other passengers, and communication in general.
Cognitive	<ul style="list-style-type: none"> • More repetition or more assurance that they are going in the correct direction or boarding the correct bus is needed. • An “On-Star” or “on-demand” information/assistance application could be developed for transit systems. • Video games can be developed to help travelers with cognitive disabilities navigate through paths in a virtual environment. • Find ways to make the transit system not so overwhelming, by providing only the needed and essential/critical information. • Create applications and devices that cue travelers to their intended path and also assist them in getting back on track if lost or veering off the correct/intended path of travel. • Technology that would allow travelers to input their station or stop onto their smartphone or other similar device, then alert the passenger (and/or driver) by signaling (e.g., buzzing) at the appropriate time to disembark/exit at the designated transit stop.
Mobility	<ul style="list-style-type: none"> • Expand “Waze-type” applications for pedestrians. • All technology solutions do not have to be high-tech. Curb-cuts are needed for persons in wheelchairs in order to make sidewalks accessible. Where there are stairs, paths, or ramps are needed. • Access to information on accessibility information such as knowing the entrances are accessible at restaurants or hotels, the condition of the sidewalk are important in planning and navigating paths.

Source: Battelle

Table 2-6. Discussion Points from the ITS and Assistive Breakout Sessions

Type of Disability	Summary of Discussion Points
Vision	<ul style="list-style-type: none"> • Personal alerts of transit vehicle availability including real-time dynamic environment information could assist in the travel of a person who is blind or has low vision. • Applications could be developed using open source data to enable trip planning capabilities. • The ideal development to assist blind travelers would be a real-time, programmable wayfinding program with virtual assistant-type capabilities that is able to “read” the environment along the way. • Automated vehicles use GPS and communicate with the ITS in the infrastructure to navigate to programmed destinations. • Applications on smartphones or portable devices can be prepopulated with trip information including transit routes and use GPS or wayfinding navigation points to identify location. • Once a request for paratransit services is placed, the pick-up and drop-off locations can be entered into a trip log system with GPS capabilities to guide drivers to the correct locations. • Sensory items, such as an ID or transit fare card can be populated with information that would alert the driver (bus, paratransit) about a person’s disability when scanned, allowing the provider to better understand the additional mobility needs of that individual. • Training sessions could be provided by different transit or commuter agencies or the local government on the use of new technological devices or smartphone apps and how they can assist travelers who are blind or have low vision.
Hearing	<ul style="list-style-type: none"> • Visual alerts in the car when an emergency vehicle is approaching are beneficial. • A device that translates speech to text would help with receiving station announcements, but also assist in communicating with drivers, other passengers, and overall communication.
Cognitive	<ul style="list-style-type: none"> • Tracking systems or devices could provide safe, independent travel for a traveler with cognitive disabilities. • Video games can be developed to help a traveler with cognitive disabilities to navigate through paths in a virtual environment. • Technology that would allow travelers with cognitive needs to receive a notification (visual or audible) that they are going the wrong way, or that would allow a traveler to input his or her station stop on their smartphone or other device.
Mobility	<ul style="list-style-type: none"> • Pedestrians with physical mobility disabilities need to know where unobstructed paths of travel are located. • The real-time operational status of equipment and services is needed.

Source: Battelle

Automation and Robotics

Automation and robotic technologies are expected to improve mobility for those unable to drive or would rather not drive. Some of the technologies used in automation and robotics include machine vision, artificial intelligence (AI), assistive robots, and facial recognition software. A majority of the workshop participants indicated that access to jobs and employment are the travel purposes most impacted (benefitted or enhanced) by Automation and Robotics, followed by recreation and leisure, medical, and shopping. Discussions about the various technological solutions that could assist travelers with disabilities and older travelers included the following:

- Virtual personal caregivers/attendants and concierge services
- Automated, driverless vehicles with communicative abilities
- Wearable/portable devices with assistive capabilities such as audio/visual, tactile, and GPS
- Automated infrastructure/vehicles (i.e., moving crosswalks, audio system guidance, etc.)
- Vision to language software development for various devices (i.e., apps, glasses, etc.)
- Assistive/collaborative robots

Some of the dependencies addressed during the workshop that could influence the success of implementing a given solution included Wi-Fi coverage in rural areas, available RFID broadcasted information, funding sources, and cost to consumers.

Table 2-7 summarizes the discussions and overall thrust of the conversations by workshop Automation and Robotics Breakout participants as they relate to the types of disabilities.

Table 2-7. Discussion Points from the Automation and Robotics Breakout Sessions

Type of Disability	Summary of Discussion Points
Vision	<ul style="list-style-type: none"> ● A virtual personal assistant could facilitate the travel of someone who is blind or has low vision by automating his or her visual capacity and providing directions to the user. ● Automated vehicles should include vision-free communication software and collision avoidance technology. ● A robot could be an alternative for guide dogs by replicating some of the routine tasks that the guide dogs typically provide. ● Glasses could be made to provide audible cues relative to the destination of the trip. ● Mobile applications could use the mobile devices embedded sensor data to provide geo-spatial information that detects and “reads” environmental objects such as stairs, pedestrian cross walks, traffic signals, and traffic signs.
Hearing	<ul style="list-style-type: none"> ● Automated vehicles could also display vehicle identification information, upcoming stop information, allow passengers to request a stop via text message, and instructions on the windshield or on a visual display such as a monitor. ● Automated messages on electronic signs in public transit stations to relay information regarding arrival times, platform/terminal assignments and delays or emergency information would be beneficial.

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Type of Disability	Summary of Discussion Points
Cognitive	<ul style="list-style-type: none"> • Buses could be equipped with monitors with both written information/instructions and a visual interpreter for illiterate passengers. • Portable, handheld devices, smartphone apps and/or other assistive technologies such as text capable glasses could translate and display conversations in real-time would be beneficial. • Tactile feedback in seats and possibly in shoes that are connected to the vehicle could provide alerts to the driver of warnings implemented by advanced driver assistance systems. <hr/> <ul style="list-style-type: none"> • A virtual concierge service could prompt users with next steps if someone was lost and also alert family members, friends, or caregivers. • Personal robots could assist with everyday tasks to reduce mobility needs such as virtual doctor's visits, fetching items around the house, and assisting with ordering grocery delivery services. • Applications that provide step-by-step instructions on how to navigate to a frequent destination would be useful. • Automated vehicles could simplify trip taking by storing personalized, regular, and familiar destination options on a touchscreen using a picture for each individual. • Verbal prompts could be used to complete necessary tasks along the way, allowing for maneuvering easily while inside the vehicle and performing other tasks/activities. • Automated light systems (headlights, high beams, and even night vision) can assist drivers who may forget to turn on headlights. • Driver monitoring systems can detect when a driver is not paying attention and alert them to return focus to the road. • Traffic sign recognition software to recognize certain traffic signs that a driver may not have noticed or was not able to read quickly enough is needed.
Mobility	<ul style="list-style-type: none"> • Automated vehicles could be programmed to deploy a wheelchair ramp. For those with severe physical disabilities, a remote control or button to activate automatic doors along with the ramps may be needed. • Advanced driver assistance systems (ADAS) providing technologies that automate safety features should be included in passenger vehicles. • Robots that can provide more physical capabilities such as lifting and grasping would be helpful with basic household activities. • Automated systems on buses, trains, and paratransit vehicles such as ramps, assistive walking devices, and door open/close should be developed. • Automated pedestrian infrastructure features such as technologies that would allow extension of traffic signal interval during pedestrian crossing or heated sidewalks would be beneficial.

Source: Battelle

Data Integration

Data integration technology works by integrating user profile information with service/infrastructure information. The technology area has two main aspects that are separated by the information that travelers with disabilities need and the information that travelers with disabilities can provide. This technology area includes solutions that enable the integration of data and information systems to create new accessible transportation applications. For example, someone who has a cognitive disability or an older adult may need an alert (on their mobile device) to let them know their bus stop is approaching. Travelers with disabilities need in-depth accessibility information about points of interest (POIs), infrastructure, facility amenities, and potential obstacles, integrated with maps and other information for their intended route. In addition, a traveler can provide his or her specific information to build a standardized user profile for a person with accessibility needs that allows for location based services both locally and nationally. After a standardized user profile is created, this would allow for more interoperable and seamless travel in a multimodal transportation system. Based on the user profile, applications can be developed to provide alerts in advance of a user’s trip requiring special accommodations.

The majority of the workshop participants indicated that there was no single purpose of travel that would be most impacted by Data Integration. Data standards emerged as an important area that needs careful consideration. To integrate user profiles, information, and databases, data needs to be accurate, and easily shared and passed to different entities. Other discussions focused on the apparent need for persons with disabilities to “self-identify” and have to create a profile – in contrast to travelers without disabilities. Other considerations discussed by participants were in the safety, security, and anonymity of the profile and the information that is exchanged.

Table 2-8 summarizes the discussions and overall thrust of the conversations by workshop Data Integration Breakout participants as they relate to the types of disabilities.

Table 2-8. Discussion Points from the Data Integration Breakout Sessions.

Type of Disability	Summary of Discussion Points
Vision	<ul style="list-style-type: none"> • Audible information along with Accessible Pedestrian Signals could assist in providing safer and uninterrupted travel conditions for a pedestrian. • Data could be bundled from crowdsourcing and used to generate route-specific alerts similar to traffic reports, but for pedestrians.
Hearing	<ul style="list-style-type: none"> • Travel information could be offered in multiple formats suitable for travelers with different mobility needs.
Cognitive	<ul style="list-style-type: none"> • Tools and applications that “remind and reinforce” travel plans should be created. • Transit data such as schedules, delays, incidents, etc. need to be accurate. Therefore, transit data must be continuously updated as schedules change or delays occur.
Mobility	<ul style="list-style-type: none"> • Pedestrians with physical mobility disabilities need to know where unobstructed paths of travel are located. • Integrating crowd sourced data with the next train arrival data, travelers with mobility needs would have better options to plan their trip. • Accessibility data need to be streamlined and standardized in order to facilitate seamless interagency/inter-entity sharing.

Source: Battelle

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Enhanced Human Services Transportation

The Enhanced Human Services Transportation technology area focuses on real-time, multimodal trip and services planning and traveler decision support applications. The technologies assist travelers with finding and choosing accessible transportation solutions that best meet their mobility needs. Enhanced Human Services Transportation technology includes the concept of transportation providers coordinating their services for more seamless travel for the user, and more efficient operations for transportation providers. It provides trip planning and information that integrates multimodal options into a complete origin to destination trip.

One half of the participants who answered the question on travel impacts indicated that jobs and employment are the travel purpose most impacted by Enhanced Human Services Transportation; this was followed by employment/training and all areas of travel. Policy harmonization emerged as an important topic for enhanced human services transportation.

Table 2-9 summarizes the discussions and overall thrust of the conversations by workshop Enhanced Human Services Transportation participants as they relate to the types of disabilities.

Table 2-9. Discussion Points from the Enhanced Human Services Transportation Breakout Sessions

Type of Disability	Summary of Discussion Points
Vision	<ul style="list-style-type: none"> • Audible interpretation of all visual sign messages at a transit station is an option. • The development of wayfinding applications that can allow travelers to plan trips across multiple transportation providers and provide auditory features and signals that enhance the traveler’s experience are needed.
Hearing	<ul style="list-style-type: none"> • Verbal announcements need to be supplemented with visual signage that could be a display in the vehicle or the translated message/announcement could be sent as a text message to a personal mobile device.
Cognitive	<ul style="list-style-type: none"> • Tracking systems or devices could provide safe, independent travel for a traveler with cognitive disabilities. • Photographs of landmarks can be included in the itinerary of a traveler with cognitive disabilities. • Information should be delivered in a simple, step-by-step manner and standardized wherever possible to reduce the need for extensive or additional training.
Mobility	<ul style="list-style-type: none"> • Travelers with physical mobility need to know if the bus or train they are waiting on has available slots for their wheelchair or mobility device. • Travelers with physical mobility needs require detailed information about their entire trip. • Web based tools or applications that integrate trip planning and provide last mile options are needed.

Source: Battelle

Participants were asked which purpose of travel would be most impacted for each technology area, and their responses were recorded on the data collection sheets. Access to “jobs/employment” was the predominant travel purpose that was identified by workshop participants as the one that could benefit most from the existing or future technological advancements and solutions under the ATTRI

Program. The second high-ranking travel purpose was identified by workshop participants as “recreation/leisure.”

Table 2-10 provides the summary of travel purposes most impacted by technology area.

Table 2-10. Travel Purposes Most Impacted by Technology Area

Technology Area	Education/ Training	Jobs/ Employment	Medical	Recreation/ Leisure	Shopping	Other
Automation and Robotics		X				
Data Integration	X	X	X	X	X	X
Enhanced Human Services Transportation		X				
ITS and Assistive Technologies		X				
Wayfinding and Navigation Solutions				X		X

Source: Battelle

Chapter 3 Synthesis of Findings

Access to transportation is an extremely important policy issue for people with mobility needs. People with disabilities, Veterans with disabilities, and older adults have the same travel expectations as individuals with unrestricted mobility. Regardless of the sub-segment of the population, many of the fundamental user needs for these groups were found to be very similar across the literature review, webinars, and workshop. The participant responses from the webinars and workshop, coupled with the literature review, clearly demonstrate that people with mobility needs face significant transportation barriers and have many different types of needs and barriers to their travel.

The literature review also provided a perspective into the characteristics of disabilities within the overall categories of visual, hearing, cognitive, and mobility disabilities. Whereas webinars focused on soliciting input from the sub-populations targeted by the ATTRI initiative, the workshop sought to align the needs and barriers faced by each type of disability with potential technologies that may be capable of meeting these needs and overcoming these barriers. In particular, discussion revolved around the five technology focus areas defined by U.S. DOT as: (1) Wayfinding and Navigational Solutions, (2) Assistive Technologies, (3) Automation and Robotics, (4) Data Integration, and (5) Enhanced Human Services Transportation. During breakout sessions focusing on these focus areas, specific types of technology needs were identified as potentially providing avenues for technology insertion to address a significant portion of the needs and barriers of persons with disabilities.

The following chapter provides a synthesis of the findings from all three activities for each of the five ATTRI technology focus areas. Chapter 4 provides a reorientation of these same findings for each of the targeted sub-segments of the population.

Synthesis of Findings by Technology Focus Area

As observed by participants in the workshop and reflected in feedback gathered from those participants, each of the five technology focus areas have the potential to address needs and overcome barriers to travel across all four types of disabilities. However, the user needs and potential solutions identified through the activities of this project varied across the technology focus areas, and a single technology focus area could not address all possible needs and barriers. Many of the focus areas are orientated towards solutions for primarily one or two types of disabilities, although persons with the remaining disability types may also benefit. Table 3-1 provides a crosswalk of the types of user needs and barriers and aligns each of the five technology focus areas to assess the level of potential for addressing the need or overcoming the barrier based upon the information provided by workshop participants on potential technology solutions and webinar participants on access to technology. Technology focus areas that were assessed as “Strong” were those where a direct connection and linkage between the user need/barrier were identified across multiple sources of information. Technology focus areas that were assessed as “Some” were those areas where the technologies were not *consistently* or *uniformly* identified as a potential solution for addressing the user need or barrier. Technology focus areas that were assessed as “Limited” generally were not identified as potential solutions, or were identified only by a very small number of sources.

Table 3-1. Crosswalk of User Needs/Barriers with Technology Focus Areas

User Needs/ Barriers	Type of User Need/ Barrier	Wayfinding and Navigation	Assistive Technologies	Automation and Robotics	Data Integration	Enhanced Human Services
User Needs	Information	Strong	Strong	Some	Some	Strong
	Options	Limited	Some	Strong	Limited	Strong
	Assistance	Limited	Some	Some	Some	Some
	Access	Limited	Some	Strong	Limited	Limited
Barriers	Adverse Perception of Travel	Strong	Strong	Some	Limited	Strong
	Cost	Limited	Some	Some	Limited	Some
	Inadequate Infrastructure Signage or Wayfinding Tools	Strong	Strong	Strong	Limited	Limited
	Inadequate Transportation Options and Amenities	Limited	Some	Strong	Limited	Strong
	Lack of Technology Access	Some	Strong	Limited	Some	Some
	Lack of Travel Support/Customer Service	Some	Some	Strong	Strong	Limited

Source: Battelle

Wayfinding and Navigational Solutions

This focus area consists of exploration and development of situational awareness and assistive navigation solutions that can provide obstacle avoidance and intelligent wayfinding capabilities for indoor and outdoor environments. These solutions can potentially assist with waypoint navigation, path planning, and advanced warning of events by using Global Positioning System (GPS), Geographic Information Systems (GIS), and ITS equipment and technologies. These applications can recognize and detect stationary objects (e.g., doors, elevators, stairs, crosswalks, and traffic lights), read and recognize important text and signage based on a user's query, and detect, track, and represent moving objects and dynamic changes to a traveler's environment (e.g., people, shopping carts, doors opening, and moving vehicles). Wearable sensors, such as cameras, three-dimensional orientation devices, and pedometers, may be used in conjunction with a display unit to provide auditory and tactile guidance.

Wayfinding and Navigational solutions have a significant potential to meet the needs of persons with visual, hearing, cognitive, and to a lesser extent mobility disabilities. Individuals will be empowered to travel more confidently and independently by using technologies in this application area that encompass both safety and mobility-centric applications. There are many different Wayfinding and Navigational solutions that were identified among the “best practices” in the literature review and by participants of the workshop. These include offering both visual and audible signage, use of braille on handrails and placards, and other such solutions. The majority of these solutions focused upon needs and barriers associated with information (or lack of) before and during travel. Applications that provide information such as the contents of signs, locations and status of transit vehicles, and pathfinding in alternative formats were cited as potential solutions for addressing the needs for users to receive more timely and detailed information.

Wayfinding and navigational solutions can also serve needs or alleviate barriers other than those classified as “Information.” For example, they can provide a person with an improved sense of situational awareness and familiarization with their surroundings either prior to the trip through technologies such as gaming and computer visualizations to real-time solutions to enhance awareness during a trip such as a wearable sensor that emits tones when the traveler strays from their desired path. Additionally, mobile devices such as cellular phones, tablets, and portable computers can also enhance situational awareness as a “heads-up” display and navigation guidance. These technologies could improve a person’s travel “Options” and help to overcome their “Adverse Perception of Travel” by providing less crowded, fully operational travel options.

Table 3-2 provides a crosswalk of the types of User Needs and Barriers against examples of potential Wayfinding and Navigation technology solutions identified by webinar and workshop participants. As noted in the table, there were many different types of technology solutions that were identified to address user needs and barriers ranging from devices that would be encountered during the trip, such as “talking signs” to “wearable sensors” to technologies that would be used prior to the initiation of travel, such as video games or computer-generated simulation visualizations. In general, wayfinding and navigation technologies were identified across most of the user needs and barriers suggesting that this area would benefit from additional research and focus.

Table 3-2. Crosswalk of User Needs and Barriers by Example Wayfinding and Navigational Solutions

User Needs/ Barriers	Type of User Need/ Barrier	Examples of Wayfinding and Navigation Technology Solutions						
User Needs	Information	<table border="1"> <tr> <td data-bbox="583 1444 764 1465">Amenities/Facility</td> <td data-bbox="781 1444 1401 1499">• “Talking signs” and audible information about fixed objects</td> </tr> <tr> <td data-bbox="583 1556 764 1667">Real-Time Schedule (Arrival/ Departures, Duration)</td> <td data-bbox="781 1556 1401 1610">• Mobile device that can automatically translate speech-to-text or text-to-speech.</td> </tr> <tr> <td data-bbox="583 1703 699 1793">Destination/ Connection Notification</td> <td data-bbox="781 1703 1401 1793">• Wearable sensors and devices that provide visual, tactile, and/or audible alerts at the appropriate time to disembark/exit at the designated transit stop</td> </tr> </table>	Amenities/Facility	• “Talking signs” and audible information about fixed objects	Real-Time Schedule (Arrival/ Departures, Duration)	• Mobile device that can automatically translate speech-to-text or text-to-speech.	Destination/ Connection Notification	• Wearable sensors and devices that provide visual, tactile, and/or audible alerts at the appropriate time to disembark/exit at the designated transit stop
Amenities/Facility	• “Talking signs” and audible information about fixed objects							
Real-Time Schedule (Arrival/ Departures, Duration)	• Mobile device that can automatically translate speech-to-text or text-to-speech.							
Destination/ Connection Notification	• Wearable sensors and devices that provide visual, tactile, and/or audible alerts at the appropriate time to disembark/exit at the designated transit stop							

User Needs/ Barriers	Type of User Need/ Barrier	Examples of Wayfinding and Navigation Technology Solutions
	Trip Planning	<ul style="list-style-type: none"> • Video games can be developed to help travelers with cognitive disabilities navigate through paths in a virtual environment.
	Landmarks/ Navigational Waypoints	<ul style="list-style-type: none"> • Real-time visual mapping using simultaneous localization and mapping (SLAM) technology • A virtual guide dog could provide indoor and outdoor navigation. • Wearable sensors and devices that provide visual, tactile, and/or audible alerts for navigating/traversing a transit terminal or stop.
	Options	<ul style="list-style-type: none"> • “Waze-type” applications for pedestrians.
	Assistance	<ul style="list-style-type: none"> • An “On-Star” or “on-demand” information/assistance application could be developed for transit systems.
	Access	<ul style="list-style-type: none"> • None identified by participants
Barriers	Adverse Perception of Travel	<ul style="list-style-type: none"> • Video games can be developed to help travelers with cognitive disabilities navigate through paths in a virtual environment. • “Waze-type” applications for pedestrians.
	Cost	<ul style="list-style-type: none"> • Ridesharing and car sharing applications and services
	Inadequate Infrastructure Signage or Wayfinding Tools	<ul style="list-style-type: none"> • Wearable sensors and devices that provide visual, tactile, and/or audible alerts for navigating/traversing a transit terminal or stop • “Talking signs” and audible information about fixed objects • Mobile device that can automatically translate speech-to-text or text-to-speech
	Inadequate Transportation Options and Amenities	<ul style="list-style-type: none"> • Applications that provide information on “nearest” transit location with the needed amenity
	Lack of Technology Access	<ul style="list-style-type: none"> • “Talking signs.” That is, infrastructure components that are more accessible.
	Lack of Travel Support/Customer Service	<ul style="list-style-type: none"> • Mobile device that can automatically translate speech-to-text or text-to-speech. • An “On-Star” or “on-demand” information/assistance application could be developed for transit systems

Source: Battelle

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Assistive Technologies

This technology focus area includes a broad range of wireless and sensor-based communications and information technology as employed in ITS, as well as other supporting technologies that can create new innovative accessible transportation solutions. The technologies include the traditional accessible, assistive, and adaptive devices that currently help with daily living activities and new nomadic or carry-on devices. Together, these technologies will help track the user’s movements, infer map information, and discover key sensor signatures to create routes and provide information in different accessible communication formats – audible, tactile, and haptic. The devices used may include new innovations from the “the Internet of Things (IoT)” being applied to wearable technology such as wrist bands, glasses, clothing, or others. These technologies also integrate with vehicles, infrastructure, and pedestrians using Dedicated Short Range Communication (DSRC) or other communication technologies to provide vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P) communications allowing for connectivity throughout a trip. This area also includes other emerging technologies within the connected vehicle, connected automation, and connected cities initiatives under the U.S. DOT’s connected vehicle research program.

Focused upon the fusion of wireless and sensor-based communication tools combined with portable or wearable technologies, Assistive Technologies mainly include personal alerts to a traveler of a particular condition such as transit vehicle availability, environmental information, and emergency situations. These alerts provide for an increased level of situational awareness of the traveler with disabilities and provide the traveler with travel options and an overall smoother travel experience. For example, through the use of a body camera, a personal device such as a smartphone could alert travelers that they are no longer in the confines of a crosswalk; or it could alert travelers about an approaching transit vehicle, and about upcoming stops while on the transit vehicle.

Table 3-3 provides a crosswalk of the types of user needs and barriers against examples of potential Assistive Technology solutions identified by webinar and workshop participants. In many of the solutions identified by the participants, the same solutions as were identified for wayfinding and navigation were also identified in this session. However, some additional technologies were identified including autonomous vehicles and the use of individualized tracking systems. In general wayfinding and navigation technologies were identified across most of the user needs and barriers suggesting that this area would benefit from additional research and focus.

Table 3-3. Crosswalk of User Needs and Barriers by Example Assistive Technology Solutions

User Needs/ Barriers	Type of User Need/ Barrier	Examples of Assistive Technology Solutions	
User Needs	Information	Amenities/Facility	<ul style="list-style-type: none"> • A device that translates speech-to-text or text-to-speech
		Real-Time Schedule (Arrival/ Departures, Duration)	<ul style="list-style-type: none"> • Personal alerts of transit vehicle availability including real-time dynamic environment information
		Destination/ Connection Notification	<ul style="list-style-type: none"> • Personal alerts of transit vehicle availability including real-time dynamic environment information

User Needs/ Barriers	Type of User Need/ Barrier	Examples of Assistive Technology Solutions
	Trip Planning	<ul style="list-style-type: none"> • Video games can be developed to help a traveler with cognitive disabilities to navigate through paths in a virtual environment.
	Landmarks/ Navigational Waypoints	<ul style="list-style-type: none"> • Real-time, programmable wayfinding program with virtual assistant-type capabilities that is able to “read” the environment along the way. • Applications on smartphones or portable devices can be prepopulated with trip information including transit routes and use GPS or wayfinding navigation points to identify location.
	Options	<ul style="list-style-type: none"> • Automated vehicles use GPS and communicate with the ITS in the infrastructure to navigate to programmed destinations
	Assistance	<ul style="list-style-type: none"> • Tracking systems or devices could provide safe, independent travel for a traveler with cognitive disabilities. • Technology that would allow travelers with cognitive needs to receive a notification (visual or audible) that they are going the wrong way, or that would allow a traveler to input his or her station stop on their smartphone or other device. • Virtual caregivers/concierge services, such as, en-route assistance to find travel alternatives • Wearable sensors and devices that provide visual, tactile, and/or audible alerts at the appropriate time to disembark/exit at the designated transit stop or for navigating/traversing a transit terminal or stop.
	Access	<ul style="list-style-type: none"> • Assistive devices, such as a white cane with environmental sensors to detect hazards (e.g. black ice) or tactile navigation/information device for individuals who are deaf-blind or proximity-based public announcements through text-based messaging
Barriers	Adverse Perception of Travel	<ul style="list-style-type: none"> • Virtual caregivers/concierge services, such as, en-route assistance to find travel alternatives
	Cost	<ul style="list-style-type: none"> • None identified by participants.
	Inadequate Infrastructure Signage or Wayfinding Tools	<ul style="list-style-type: none"> • Wearable sensors and devices that provide visual, tactile, and/or audible alerts at the appropriate time to disembark/exit at the designated transit stop or for navigating/traversing a transit terminal or stop. • Technology that would allow travelers with cognitive needs to receive a notification (visual or audible) that they are going the wrong way, or that would allow a traveler to input his or her station stop on their smartphone or other device.

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User Needs/ Barriers	Type of User Need/ Barrier	Examples of Assistive Technology Solutions
		<ul style="list-style-type: none"> Virtual caregivers/concierge services, such as, en-route assistance to find travel alternatives
		<ul style="list-style-type: none"> Automated vehicles use GPS and communicate with the ITS in the infrastructure to navigate to programmed destinations
	Inadequate Transportation Options and Amenities	<ul style="list-style-type: none"> Automated vehicles use GPS and communicate with the ITS in the infrastructure to navigate to programmed destinations
	Lack of Technology Access	<ul style="list-style-type: none"> None identified by participants.
	Lack of Travel Support/Customer Service	<ul style="list-style-type: none"> Virtual caregivers/concierge services, such as, en-route assistance to find travel alternatives

Source: Battelle

Automation and Robotics

Automated vehicles and robotics are expected to improve mobility for those unable or unwilling to drive and enhance independent and spontaneous travel capabilities for travelers with disabilities. One area of particular interest is exploring the use of vehicle automation to solve first mile/last mile mobility issues, providing connections for all travelers to existing public transportation or other transportation hubs. Applications in this area also include collaborative robots that not only assist with activities in daily life such as walking, but also work with individual travelers and human transportation services to provide related concierge services at different stages of their travel to improve personal mobility across the transportation network. Machine vision, artificial intelligence, assistive robots (potentially partially humanized), and facial recognition software in vehicles, mobile or hand-held devices, and terminals that solve a variety of travel-related issues for people with disabilities are also included. Such technology can be used to create virtual caregivers/concierge services and other such applications to guide travelers and assist decision making.

Much of the discussion, literature review, and feedback from the webinars and workshop on Automation and Robotics focused upon either the use of robotics or advanced analytics to serve as a surrogate “virtual personal assistant,” as well as automotive or travel options that are “self-driving” or “self-operating.” A number of the solutions discussed during the workshop could be used in a variety of configurations to assist someone who has a disability. A virtual personal assistant could facilitate travel for someone who has a disability by augmenting their visual, hearing, or cognitive capacity and providing direction or information to the user. Virtual assistance can be in the form of a concierge service or a caregiver that connects with the user’s device and, in a sense, becomes “the eyes” or “the ears” of the user. This can be done through portable devices with video transmission capability, such as a smartphone or tablet. This technology could also assist those with navigating in crowded areas such as transit stations with assistance to reach the correct platform or bus terminal. A virtual personal assistant would certainly fill many of the user needs and alleviate barriers revolving around the need for and lack of information before and during travel. Additionally, the virtual personal assistant would help to overcome the Adverse Perception of Travel barrier, as well as improving

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assistance and generating alternative options for travel. It is important to note that a virtual personal assistant could be implemented in many different forms and configurations ranging from a mobile device application, real-time video/audible chat, wearable technologies such as Google Glass™, as well as “on-demand virtual concierge service” infrastructure components that can be accessed by persons with disabilities, as needed.

Self-driving or self-operating vehicles and “people movers” were frequently presented as solutions to enhance travel options, overcome navigation and wayfinding challenges, and improve access to a wider spectrum of destinations for persons with disabilities. This solution would meet all of these needs and barriers, because they remove the need for the individual traveler to navigate through the transportation system. These vehicles can be programmed to automatically arrive, pick-up passengers, and deliver them to their destinations without the need for an extensive information exchange between the traveler and the transportation system. Vehicles would be programmable to provide the traveler with flexibility in his or her travels.

Workshop suggestions for this technology for the travelers who are blind or have low vision included supplying the vehicle with a communication software, similar to Siri®, the intelligent personal assistant available on the iOS 5 platform and higher (Apple’s Operating System), which enables the passenger to verbally input the desired destination. However, full automation is not necessarily required for improvements to mobility among persons with disabilities. Partial autonomous vehicles (i.e., those that at least have some limited cognizance of their surroundings) also have the potential to improve mobility as they can reduce the cognitive workload of the driver, as well as augmenting a person’s vision, hearing, and cognitive senses through sensor suites and analytics that can process and alert the driver of obstacles, avoid collisions, and provide a more robust situational awareness for the driver in real-time. For example, on-board systems could monitor the surrounding external environment for sounds that would be indicative of an eminent danger (e.g., honking horns, squealing tires, etc.) and provide this as a visual alert to a driver with a hearing disability. Alternatively, an optical sensor could automatically “read” on-coming road signs, translate the information to audible voice, and provide this to a driver with a vision disability.

Ultimately, automation and robotics may be an area where additional research and adoption of these technologies would greatly increase the mobility of persons with disabilities.

Data Integration

This technology focus area includes solutions that enable the integration of data and information systems to create new accessible transportation applications. This technology area has two main aspects: information that travelers with disabilities need, and information that travelers with disabilities can provide. Travelers with disabilities need in-depth accessibility information about points of interest, infrastructure, facility amenities, services, and potential obstacles, integrated with maps and other information for their intended route. This map integration is a key aspect for data integration as a technology solution. In particular, locating points of interest, facility amenities, and potential obstacles geographically in relation to the person provides options for selection of different routes and modes. In addition, a traveler can provide his or her specific information to build a standardized user profile for a person with accessibility needs that allows for location-based services both locally and nationally. Based on a user’s profile, applications could be developed to alert relevant authorities in advance of a user’s trip requiring special accommodations, such as a wheelchair at a transit terminal.

Data Integration, by nature, can support the user needs associated with the Lack of Travel Support/Customer Service barrier. In concept, persons with disabilities could develop a standardized travel profile that could be shared among the various transportation providers to ensure that a

seamless end-to-end trip that has all of the requisite accommodations for the individual traveler met. Such a profile would improve mobility, as it would reduce the need for a person with a disability from having to search for and secure “customized” services during their travel. These accommodations and services would be automatically established prior to the trip departure through communication of the traveler’s profile.

An important aspect of Data Integration that is increasing in popularity and adoption due to the increased usage and acceptance of social media is the “crowdsourcing” of information. Data could be bundled from crowdsourcing and used to generate route-specific alerts similar to traffic reports, but for pedestrians. For example, pedestrians could input their origin and destination to obtain detailed route information tailored for the specific needs of a traveler who is blind or has low vision. The report could include information and alerts such as cracked sidewalks, construction zones, closed sidewalks, due to construction, obstructions along the path such as fire hydrants, trees, utility poles, etc.

Data Integration has particular potential to benefit travelers with cognitive disabilities. Social applications such as Find My Friends™, Glympse™, and Google+™ can be used as a tracking mechanism for monitoring travel and providing assistance, if needed, to a traveling person with a disability. Alternatively, the person with the disability could use these same applications to identify nearby trusted persons whom they could seek out for assistance. These types of applications would, therefore, provide greater traveling options and mechanisms for receiving assistance during a trip, which may, in turn, help to overcome the Adverse Perception of Travel barrier.

The benefits of Data Integration may be also especially useful to travelers who live in rural areas, as non-traditional or community-based transportation services in rural areas generally do not have an ubiquitous ability to accommodate all types of disabilities (e.g., wheelchair ramps/access). This positions data integration solutions to serve Older Adults and Veterans with Disabilities particularly well, as these sub-populations live in rural areas at higher rates than the general population. Having this information in a standardized format and database may also facilitate the coordination of transportation between public and third-party providers and decrease the overall number of trips within the transportation system by matching travelers with disabilities to providers with the appropriate ability to provide service.

One challenge with the use of Data Integration technology identified by participants, as well as during the literature review, is that many governmental entities and persons view a travel profile that contains specific mobility requirements as personally identifiable information (PII). Therefore, Health Insurance Portability and Accountability Act (HIPAA) laws must be followed to ensure that the safety and security of the information and data are addressed along with the maintenance of data issues. This may limit the ability to share this information among transportation providers who, as an industry, generally do not maintain or interact with this type of information.

Overall Data Integration Technologies provides a potential source of technology solutions that can be developed and adopted to improve the mobility of persons with disabilities. At the same time, however, additional research is needed to determine how these solutions can be made to be individualized or personalized to an individual traveler while still providing for anonymity. Overall, Data Integration Technologies were thought to be best suited to address needs and barriers associated with customer support and service.

Enhanced Human Services Transportation

The focus of this technology area is real-time, multimodal trip and services planning and travelers' decision support applications that assist travelers with finding and choosing accessible transportation solutions that best meet their mobility needs. A key aspect of Enhanced Human Services Transportation is the coordination between agencies, jurisdictions, and non-profit organizations to maximize transportation services for people with disabilities, Veterans with Disabilities, and older adults to eliminate service gaps and to facilitate better service, communication and affordability across jurisdictions. This may include pre-trip planning and information that integrate multimodal options into a complete origin to destination trip. Applications in this area include an integrated payment system where travelers can use the same smart card or mobile applications to pay for various types of transportation, mobility options, and parking. Other applications of interest are linking paratransit, demand-response transportation, and fixed-route transit in order to increase flexibility and options of travelers with disabilities.

Enhanced Human Services Transportation requires coordination and collaboration across entities and, therefore, has many inherent challenges and barriers to implementation and realization that all such programs and initiatives have. However, if successful, Enhanced Human Services Transportation programs can have a noticeable impact on the mobility of persons with disabilities, as the overall transportation experience, from trip planning through trip conclusion can be much more streamlined, integrated, and require less effort by the traveler with disabilities. In terms of technologies, this focus area emphasizes aspects of technology that are the "building blocks" for applications and systems. For example, industry standards or guidelines on payment and trip planning systems are examples of some of the requisite building blocks.

With the advent of many new technology solutions, there is the need to harness these solutions to best serve the needs of travelers with disabilities. The Mobility Services for All Americans (MSAA) initiative is a prime example of enhanced human services transportation. MSAA aims to improve transportation for the disadvantaged and the general public to access employment, healthcare, education, and other community activities through a physical or virtual Travel Management Coordination Center (TMCC) that use ITS technologies and allows stakeholders to work together.

Technologies associated with Enhanced Human Services Transportation were identified repeatedly in the literature review, during the webinars, and at the workshop as potential technologies that would address many user needs and barriers. Further research in this technology area should be conducted to identify the specific technologies that would reduce institutional barriers for collaboration, improve system interoperability, and work together to create a seamless travel options for persons with disabilities.

Chapter 4 Conclusions and Next Steps

Conclusions

There are many themes that emerged as a result of the research for the ATTRI User Needs: Stakeholder Engagement task. First and foremost, based upon the literature review, webinar responses, and the discussion among participants at the workshops, persons with disabilities, Veterans with Disabilities, and older adults clearly have significant needs and barriers to mobility. Although needs and barriers are unique for each person, several trends were observed to emerge regarding the needs, barriers, and potential technology solutions to address and overcome these needs and barriers. These overarching themes include:

- **Information** for Travelers with Disabilities, the most frequently-identified category of user need, is a critical component for mobility. Existing and emerging technologies in the areas of Wayfinding and Navigation and Assistive Technologies present strong opportunities to meet the information needs of travelers with disabilities.
- Providing travel **Options** to travelers with disabilities before and during their travel enhances the trip experience and increases the probability of an uninterrupted trip. The Enhanced Human Services Transportation focus area is well-suited to facilitate enhanced traveler options through coordination between agencies, jurisdictions, and non-profit organizations.
- More travel **Assistance** could be given to travelers with disabilities during their travel, particularly in the forms of Assistive Technologies, Automation and Robotics and Data Integration.
- **Access** to transportation assets could be enhanced through technology solutions, but most traveler needs related to access pertained to information about access-related amenities.

The following summarizes the conclusions within each of these four overarching themes.

Conclusions on Providing “Information” to Travelers with Disabilities

Having access to information prior to and during a trip was overwhelmingly reported by participants in the outreach activities of this project, as well as documented by other researchers and reported in the literature review. Many different needs and solutions around information have been identified, but generally fall into a small number of groupings such as:

- Information on Amenities/Facility
- Real-Time Schedule (Arrival/Departures, Duration)
- Destination/ Connection Notification
- Trip Planning
- Identification and Notification of Landmarks/ Navigational Waypoints.

Corresponding barriers to transportation also reflect this need for information and revolve around issues or challenges that are created for the traveler if this information is not available or accessible. For example, travelers with a visual disability reported that a challenge to their travel included knowing where they were while traveling (i.e., signs and waypoints were not readily accessible for persons with a visual disability).

Although information was the most cited need and barrier to improved mobility among persons with disabilities, it is interesting to note that very few of the current “best practices” within the domestic or international transit community identified through the literature review address the inaccessibility, relative unavailability, and lack of comprehensibility of information sources for travelers with disabilities. At the same time, however, participants in this research project were readily able to provide numerous specific examples of the types of technologies that could be utilized to address this need. Technologies involving “text-to-speech” or “speech-to-text,” mobile wayfinding and navigation applications, and enhanced “assistance” technologies, such as “on-demand assistance” or virtual assistants, are frequently identified as potential solutions. Technologies that would reduce the level of information needed by travelers with disabilities, such as autonomous vehicles with pre-programmed door-to-door service, are also frequently cited.

With the notable advancement in mobile and portable computing power and the continued rise of continuously connected mobile devices, many of the technology solutions that were identified as solutions for gaps in information are very realistic for implementation within the next three to five years, if not sooner. The technologies also align well with other U.S. DOT programs and initiatives such as the Dynamic Mobility Applications, Mobility on Demand, Wellness to Work, Smart Cities Initiative, and the Connected Vehicle program. They also dovetail with advances in private industry, which is currently focusing on improving human-to-machine interfaces with mobile devices to include audible, visual (eye tracking), and gesture-based commands as well as the traditional tactile methods.

Clearly, the topic of information is an area that is ripe for pursuit by the U.S. DOT and others, as relatively immediate technology insertion would have a significant impact on improving mobility. Wayfinding and Navigation technologies tend to be the type of technologies that are most identified as being capable of meeting these needs and overcoming these barriers, but Assistive Technologies and Enhanced Human Services Transportation technologies are also very relevant and should be pursued. There are certainly challenges with these technology options, not the least of which is the reported lack of access to and utilization of technology information dissemination devices such as mobile phones, tablets, portable computers, etc. among persons with disabilities; but as the trend in technology adoption by the general public continues upward, so too should adoption among persons with disabilities.

Conclusions on Providing “Options” to Travelers with Disabilities

Travelers with disabilities need options when it comes to planning and conducting travel. Many user needs and barriers can be directly connected to the lack of or the perceived lack of travel options. In particular, travelers want to be able to have choices when planning their travel, as well as have choices available during their travel to accommodate service conditions and other factors encountered. Older adults and Veterans with disabilities, of which a significant percentage reside in rural areas, often have only a limited selection of transportation options available. While some report this directly as a user need and/or barrier, others report surrogate user needs and barriers associated with a lack of options for travel. For example, the stated need among older adults and Veterans with disabilities that reside in rural areas to have “reliable, on-time” transit service, as well as to have “vehicles with accessible equipment,” are a direct intermediate result of their having limited travel

options (e.g., in situations where these barriers were presented, they would select other travel options if they were available). Automation and Robotics technologies may provide solutions to these needs by allowing more utilization of personal automobiles by persons with disabilities. Alternatively, automation and robotic technologies may be used to address the “first mile/last mile” challenge facing many persons with disabilities experience when they try to use fixed route transit services. Data Integration and Enhanced Human Services Transportation are technology focus areas that can provide technology solutions to enhance options by addressing, through coordination and data sharing, first/last mile integration and the lack of available transportation options. Systems of information integrated into a single database across multiple agencies that can be accessed by a single piece of technology unique to the traveler would enable great personalization of services and provide travel options for that traveler that account for their individual mobility needs. For example, if payment and information systems were integrated between fixed route transit services across both public and private providers, a traveler could be informed of alternative travel routes that are suitable for their particular mobility needs. These options could be provided automatically based upon their current location and transaction with the payment system, and their individual mobility needs could also conveyed.

Travelers with disabilities also want options when it comes to facilities and amenities. They want to know prior to their trip what the transportation facility configuration is and the status of services. If unsuited or inoperable, they want alternative options for travel. At the same time, travelers with disabilities want to be notified en-route when services and/or amenities change status or become challenging for them to manage with their disability, and provided with options so they may continue their travel. Receiving real-time assistance through technology options, such as a virtual personal assistant or an electronic guide dog, are examples of technology options cited as Wayfinding and Navigation, as well as Assistive Technologies.

Having options with respect to travel improves the overall perception and attitude of the transportation system, as well as the overall quality of life for persons with disabilities. For older adults, it enhances their ability to age-in-place as they can retain more of their independence by remaining mobile. All of the technology focus areas have a role to play in potentially providing travel options either before or during a trip and should continue to be explored.

Conclusions on Providing “Assistance” to Travelers with Disabilities

Travelers with disabilities need assistance as they travel. In many cases, this assistance may be most easily provided by transit operators and transportation providers/staff. However, many of these individuals need increased levels of training that cater to a specific type of disability. Persons that have a visual disability would potentially benefit from providers that have a basic understanding of providing navigation assistance. Persons who have a hearing disability would potentially benefit from having transportation providers who have a basic level of knowledge of sign language. Persons with cognitive disabilities may require operators who have been trained to understand that the repetition and simplification of an information transfer would be beneficial. Alternatively, these operators could be equipped with technology solutions that provide visual or audible “cues” that include landmarks, pictures of destination points, etc. that are suitable for consumption and comprehension for persons with cognitive disabilities. Persons with mobility disabilities may need different kinds of assistance as they travel, such as storage or locking of wheelchairs, canes, etc., and operators should have training on how to provide this assistance.

Training of transportation providers alone will likely not resolve the need that persons with disabilities often have the need for assistance on topics such as wayfinding, trip planning, and notification of arrival at their destination/connection. Technology solutions, such as mobile tactile or audible based applications for Wayfinding and Navigation, are needed. Other solutions to address the barrier of a lack of customer support/service include technologies that employ Data Integration, such as crowdsourcing and social media applications, would also be beneficial.

Technology-based solutions to provide real-time assistance to travelers with disabilities include the use of a virtual electronic guide dog, wearable devices to provide course corrections, and even semi-autonomous technologies that detect when a traveler with a disability has departed from their expected path and automatically begin to provide real-time guidance assistance through an “on-demand virtual concierge service,” “mobile application,” or other method. Although these technologies may seem far away, many recent advances have greatly moved the state of the art towards these types of technology-based solutions. For example, it is relatively common to have mobile devices that include navigation directions that “automatically recalculate” when a user deviates from the designated path. These same conditions could also be used to trigger the initiation of a semi-autonomous assistant who could provide individual assistance to the traveler.

With the rapid development of mobile devices and services associated with providing instant help to travelers (e.g., “On-Star™”), this is a ripe technology area for adoption within the disabilities communities and could integrate many technology systems that are already in-place within the public transit system such as Computer Aided Dispatch/ Automated Vehicle Location CAD/AVL information, electronic schedules and arrival/departure times.

Conclusions on Improving “Access” to Travelers with Disabilities

Many of the current “best practices” within the transit industry involve improving the physical configurations and layouts of transportation facilities, so that they are more “accessible” to persons with disabilities. Curb cuts, raised strips indicating the edge of a transit platform, and connected and continuous pathways are examples of the types of best practices that have been deployed to improve access for persons with disabilities. These types of best practices and corresponding changes within the transportation system seem to be working. Needs and barriers associated with a lack of access were consistently cited lower than all other needs and barriers to mobility.

There were a relatively small number of potential technology solutions that were identified during this project that would contribute to improving access, although these solutions also could be typically considered as “assistive” technologies as well. Identified technologies include assistive devices, such as a white cane with environmental sensors to detect hazards (e.g. black ice), tactile navigation/information devices for individuals who are deaf-blind, and proximity-based public announcements through text-based messaging. Autonomous systems, such as fully autonomous vehicles, would also improve access to the transportation system.

Overall, further technology insertion and research into this user need and barrier will occur, but should occur as a side benefit of improvement made by technologies in one of the other three user need/barrier areas.

Next Steps

The results, findings, and conclusions in this User Needs: Stakeholder Engagement project provide insight into potential next steps for ATTRI. One obvious next step is to continue the overall mission of ATTRI as all three activities, the literature review, webinars, and workshops, clearly identified needs and barriers to mobility for persons with disabilities, Veterans with disabilities, and Older Adults. At the same time, however, this project identified several technology areas that show promise for improving mobility where additional research should be conducted.

Among the five technology focus areas identified by ATTRI, Wayfinding and Navigation shows strong potential to improve mobility. Information prior to and during a trip was consistently cited as the greatest need, and Wayfinding and Navigation technologies can help address this need. New Navigation and Wayfinding technologies, such as inexpensive Electronic Orientation Aids (EOA) for vision impaired individuals based upon RFID and mobile devices to determine a person's location and a suitable route to destination, should continue to be supported. Other technologies such as smartphone applications that combine a variety of technologies including robotics, crowdsourcing, advanced path-planning and multi-modal interfaces to provide dynamic map and real-time navigation guidance should continue. The strength of the application is its ability to annotate the route a user wants to take and invite trusted sources (individuals or organizations) to enhance urban navigation decisions by blind or vision-impaired travelers.

Assistive Technologies and Automation and Robotics also show promise for improving mobility. While technology solutions corresponding to addressing the needs and barriers associated with Assistance were not overwhelmingly identified in this project from either the literature review or from webinar and workshop participants, technology solutions for providing Information were consistently identified in all five technology focus areas. This suggests that additional research should be conducted to identify solutions to address those user needs and barriers associated with Assistance Technologies and Automation and Robotics as they relate to providing Information. Given the breadth of existing technology solutions identified for providing additional Information, additional outreach and communications on existing solutions may be more impactful than research to identify new solutions.

Data Integration and Enhanced Human Services Transportation are technology focus areas that would also benefit from additional research – particularly to conduct prototype and pilot deployments of open data exchanges, and promotion of inter-agency data and pricing systems standards, as well as new tools to foster a more seamless travel experience. The relatively few technology solutions identified in this project indicate that these technology focus areas are not as far in their lifecycle as the others, suggesting that the U.S. DOT may need to be the instrument for driving these solutions forward. In contrast, the other three technology focus areas appear to be further along in terms of an overall life cycle, possibly due to a strong engagement from the private sector in developing new technology solutions surrounding mobile devices and autonomous vehicles. U.S. DOT should capitalize upon this private sector growth and investments by enhancing these activities through focused research activities to address specific user needs and barriers.

Results from this Stakeholder Engagement and User Needs task have already begun to shape future ATTRI efforts. The user needs that emerged from this task were key inputs into identifying foundational considerations and the four (4) key focus areas for application development, which are shown in Figure 4-1.

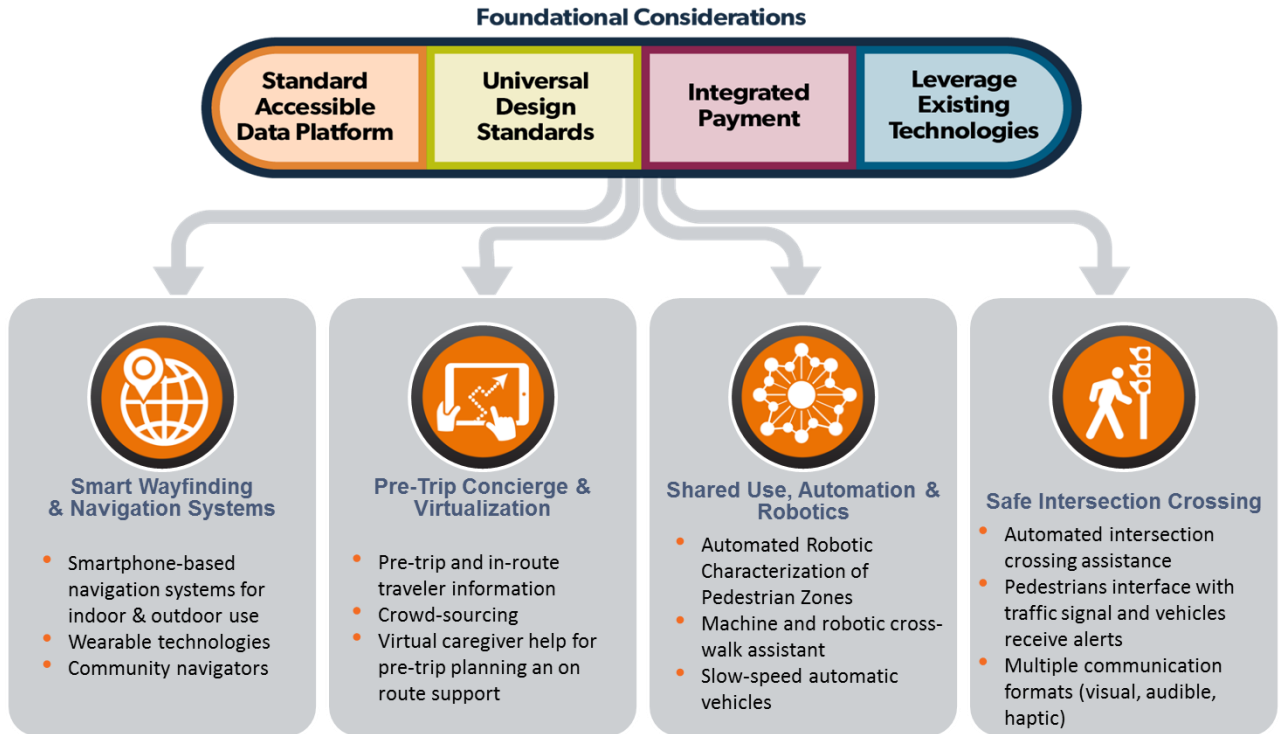


Figure 4-1. ATTRI Foundational Considerations and Key Focus Areas for Application Development

Source: U.S. DOT

As the ATTRI program moves into Phase II, continued engagement with the stakeholder community would provide valuable insights and should continue. Communications and outreach are critical as further international research coordination is performed and as applications are developed and prototyped to ensure that user needs are successfully being met. The research begun in this task will also serve as a basis for assessing institutional and policy issues related to ATTRI technology areas.

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National Aeronautics and Space Administration (NASA), U.S. Department of Energy (DOE), U.S. Veterans Administration (VA).

APPENDIX A. List of Acronyms

AARP	American Association of Retired Persons
ACS	American Community Survey
ADA	Americans with Disabilities Act
ADAS	Advanced Driver Assistance Systems
ADUS	Automated Driving for Universal Services
AIRBO	Applied Robotics for Installation and Base Operations
App	Application
APS	Accessible Pedestrian Signals
ASL	American Sign Language
ATTRI	Accessible Transportation Technologies Research Initiative
AVL	Automatic Vehicle Location
Battelle	Battelle Memorial Institute
CAD	Computer-aided Dispatch
CIP	Capital Improvement Program
CRPD	Convention on the Rights of People with Disabilities
DSRC	Dedicated Short Range Communication
EHST	Enhanced Human Service Transportation
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GIS	Geographical Information Systems
GPS	Global Positioning Systems
HIPAA	Health Insurance Portability and Accountability Act
IoT	Internet of Things
ITS	Intelligent Transportation Systems
ITS JPO	Intelligent Transportation Systems Joint Program Office
MaaS	Mobility as a Service
MAP-21	Moving Ahead for Progress in the 21 st Century
MPO	Metropolitan Planning Agency
MSAA	Mobility Services for All Americans
NIDILRR	National Institute on Disability, Independent Living and Rehabilitation Research
ODO	Open Doors Organization
OST	Office of the Secretary

R&D	Research and Development
RFID	Radio Frequency Identification
SAVI	Singapore Autonomous Vehicle Initiative
SIP	Strategic Innovation Promotion
SLAM	Simultaneous Localization and Mapping
STIP	Statewide Transportation Improvement Program
TIP	Transportation Improvement Program
TMCC	Travel Management Coordination Center
TRIS	Transportation Research Information Services
TRB	Transportation Research Board
TTI	Texas A&M Transportation Institute
TURTLE	Transport Using Technologies Leads to Economic Efficiency
UN	United Nations
U.S. DOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
VA	Veterans Administration
WHO	World Health Organization

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