Accessible Transportation Technologies Research Initiative (ATTRI)—Advancing Mobility Solutions for All

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Abstract The Accessible Transportation Technologies Research Initiative (ATTRI) leverages emerging innovations to identify, develop, and deploy new transformative technologies, applications, or systems, along with supporting policies and institutional guidance, to address mobility challenges of all travelers, in particular, travelers with disabilities. ATTRI research focuses on the needs of three stakeholder groups: people with disabilities, veterans with disabilities, and older adults. ATTRI will also develop technological solutions to lower or remove barriers to transportation according to four functional disabilities within these stakeholder groups: visual, hearing, cognitive, and mobility. The technologies potentially leveraged by ATTRI provide almost ubiquitous access to a wealth of real-time situational data sources, including data specific to transportation, municipalities, points of interest, accessibility, and crowd-sourced information.

Keywords ATTRI · Accessible transportation · Emerging technology · Accessibility data · Vehicle automation · Intelligent transportation systems (ITS) · Connected vehicles (CV) · Vehicle-to-infrastructure (V2I) communication

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1 Introduction to ATTRI

The development and, to an even greater degree, the acceptance and deployment of advanced transportation technologies is a complex process. Entrepreneurs, researchers, and futurists seem to discuss a new technological revolution almost daily. Hundreds of innovators are working to bring transformations in accessible transportation technology to assist people with disabilities and older adults. The Accessible Transportation Technologies Research Initiative (ATTRI) is a joint U.S. Department of Transportation (USDOT) initiative, co-led by the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), with support from the Intelligent Transportation Systems (ITS) Joint Program Office (JPO) and other Federal partners. ATTRI conducts research to improve the mobility of travelers with disabilities through the use of ITS and other advanced technologies. ATTRI leads the research, development, and implementation of transformative technologies, solutions, applications, or systems for people of all abilities to effectively plan their personal and independent travel.

ATTRI will enhance the capability of travelers to reliably and safely execute independent travel. ATTRI will identify, develop, and deploy new transformative technologies, applications, or systems, along with supporting policies and institutional guidance, to address mobility challenges of all travelers, particularly those with disabilities. ATTRI supports this effort with its mission to remove barriers to transportation by leveraging advanced technology to enable people to travel more easily, affordably, and effectively, regardless of their individual abilities. All applications developed under the ATTRI program shall utilize principles for all users of the transportation ecosystem, whether developing new applications that can be used by all travelers or leveraging existing solutions and enhancing them to meet user needs. As part of this mission, ATTRI is responsible for communicating its goals, objectives, research, and progress to its stakeholders and the general public.

1.1 Background

The USDOT remains a driving force in the future of accessible and inclusive transportation technologies [1]. Transportation plays a critical role in enhancing access to education, family, work, healthcare, leisure, and social activities (Fig. 1).

Research has shown that enhanced personal mobility for travelers with disabilities has a direct impact on labor force participation and increases economic activity. The USDOT acknowledges that transportation is a key driver for these systems and includes enhancing mobility as a strategic priority within the *ITS Strategic Plan (2015–2019)*. The ITS Program looks to explore methods and management strategies to increase system efficiency and improve individual mobility [2].

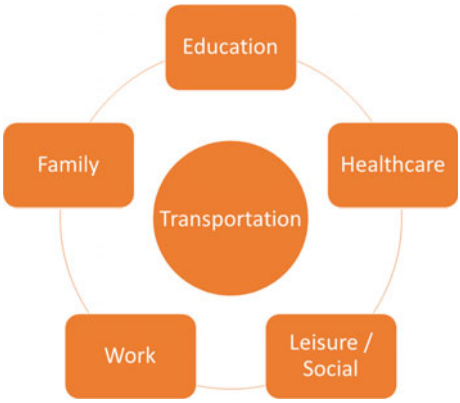

Fig. 1 Role of transportation

1.2 Challenges and Barriers

The barriers facing persons with disabilities, veterans with disabilities, and older adults–whether those challenges are manifested by virtue of vision, mobility, hearing, or cognition–are as diverse as that population itself. Approximately 56.7 million people (18.7 %) of the 303.9 million in the civilian noninstitutionalized U.S. population had a disability in 2010 [3]. Lessons from a survey of persons with disabilities in New Jersey found "76 % of all participants felt strongly that transportation was important for their job search…. When asked whether they left or refused a job offer because of travel difficulties, 25 % mentioned leaving a job and 40 % mentioned refusing a job offer because of travel difficulties" [4]. The global gross domestic product lost annually due to disability is estimated to be between $1.37 and $1.94 trillion [5]. According to a World Health Report, "over a billion people, about 15 % of the world's population, have some form of disability and rates of disability are increasing due to population ageing and increases in chronic health conditions, among other causes" [6]. The population 65 and over has increased from 35.5 million in 2002 to 43.1 million in 2012 (a 21 % increase) and is projected to increase to 79.7 million in 2040. Some type of disability (i.e., difficulty in hearing, vision, cognition, ambulation, self-care, or independent living) was reported by 36 % of people age 65 and over in 2012 [7].

Many barriers often faced by these communities include lack of accessible service; lack of available transportation; lack of signage, maps, and landmarks; navigation difficulties; inconsistent accessible pathways and infrastructure; no accessible amenities (restrooms, benches, etc.); unreliable modes of transportation; and the weather. However, by and large, the barriers can be categorized into three different categories: (1) the actual mechanics of executing an individual's transportation needs, and (2) determining how an individual could execute his/her transportation needs, and (3) communicating transportation innovations to stakeholders who may have vision, hearing, mobility and intellectual impairment.

The first category depends on the nature of the disability(ies) that an individual has. A flight of stairs or steep terrain can inhibit the mobility of those persons with mobility-related disabilities, whereas a four-stage signalized crossing at a busy intersection can seriously challenge those with any and all types of disabilities. Underlying those barriers, our team is mindful that these populations often also face the challenges of poverty. Too often, that poverty is exacerbated by the transportation challenges as they search for employment opportunities to which they can travel. Another barrier is cost. The enabling technologies must be affordable. The technologies should be innovative but simple for the older population to be able to use it without a steep or no learning curve as many of them are technology averse.

The second category is then informed and often defined by the array of challenges from the first category that lies between the traveler's origin and destination. For example, wayfinding can be as simple as helping someone with mobility challenges find a path that most quickly routes them to an elevator at their subway stop rather than first to the stairs. However, wayfinding can be as complex as providing turn-by-turn auditory and sensory instructions through a major international airport for a passenger with a visual disability. There, the wayfinding cannot only be to the passenger's departing gate, but also to an accessible restroom facility—not to mention a bite to eat or cup of coffee. Ultimately, the wayfinding should serve to make the traveler's trip as stress-free as possible.

The third category speaks to the traveler's ability to receive the information. For example, is the text too small for an elderly or vision-impaired person? Can the sound be played at a desired speed as visually impaired individuals can often process auditory messages faster than those not visually impaired? For a person with intellectual impairment, are texts or visuals in plain language easy to understand? Do visuals tell compelling stories that are simple yet informative? Communications to these stakeholders must be very clear in order to be understood and processed.

1.3 ATTRI Vision

The ATTRI program's vision is to enhance the mobility of travelers with disabilities by providing the capability to reliably, safely, and independently plan and execute their travel. The initiative identifies, coordinates, develops, and implements new integrated solutions in advancing such capabilities.

The driving purpose of this initiative is to leverage technological advances to transform the mobility of travelers with disabilities. ATTRI addresses the mobility challenges of travelers with disabilities by identifying, developing, and deploying new applications or systems that support policies and institutional guidance. The initiative focuses on the needs of three stakeholder groups: people with disabilities, veterans with disabilities, and older adults (Fig. 2).

Fig. 2 Targeted populations of the ATTRI program plan

Through ATTRI, technological solutions will be developed to lower or remove barriers to transportation according to four functional disabilities: visual, hearing, cognitive and mobility.

1.4 User Needs Identified

In its ongoing effort to gain valuable information from the public, the USDOT conducted outreach and stakeholder engagement activities, including a series of webinars to identify user needs and challenges faced by a variety of ATTRI stakeholders, including, but not limited to, the three main stakeholder groups that were previously listed. The webinars were interactive and walked participants through several scenarios to gather responses and feedback. These webinars were very interactive and participants shared a wealth of information to assist us in identifying and growing our understanding of user needs.

Based on the barriers identified earlier, a set of needs can be developed. These include the need for amenity information ahead of time (availability of accessible restrooms, benches, shelter, etc.), real-time transportation information (to help with connections), (traveler helpline or customer service), consistent accessible pathways, destination information (entrances, elevators, layout, etc.), mapping (for directions), roadway/pathway real-time conditions (during adverse weather) and personal care attendant or other assistive services. Using innovative and simple technology can help address almost all needs, but there are issues with technology as well that need to be kept in mind, while developing applications.

For example, applications need to work with existing systems in place, have a systematic maintenance schedule, be reliable, and most importantly be immunized to data confidentiality breaches/theft. Technology initiatives can address several problems these target populations face on a daily basis. For example, a network of ITS technologies can be used to reduce or eliminate the safety risks associated with an at-grade street crossing by communicating to vehicles the presence and needs of a crossing pedestrian. Automated vehicles and personal mobility can serve to elegantly tunnel through the entire landscape of barriers by providing technologies whose demands of the traveler are independent of the traveler's abilities—namely, the traveler may only need to know where they want to go and need to provide no other input, physical, cognitive or otherwise. Robotics and artificial intelligence can

be invaluable resources for wayfinding as assistants to the traveler. Accessible data can be the foundation of all wayfinding applications as those data codify the existence of the barriers of individual traveler's objective function, enabling personalized and mathematically simple path optimization. These technologies should serve to reduce how onerous various features are along a differently-abled traveler's path and also reduce how onerous the path is on the whole provided each individual's unique set of abilities and challenges.

1.5 Collaboration

As a USDOT joint research and development initiative, ATTRI is co-led by Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), with support from ITS Joint Program Office (ITS JPO) and other Federal agencies, such as the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR). The USDOT recognizes the interdisciplinary nature of accessible transportation research and actively seeks opportunities to leverage resources, accomplishments, and knowledge transfer, both within USDOT as well as across Federal agencies. ATTRI has established collaborations with key federal partners and other organizations to leverage technologies and innovations from Federal ITS and related disability research and development activities. Key partners include the Interagency Committee on Disability Research (ICDR); the U.S. Access Board; the U.S. Army Tank Automotive Research, Development, and Engineering Center (TARDEC); as well as other public and private organizations.

2 ATTRI Technology Research Solutions

Potential applications to be developed under ATTRI will leverage advances in vehicle and infrastructure-based technologies, automation, robotics, and wireless communication. Other USDOT research program areas and emerging innovations (such as assistive robots and crowdsourcing) could help produce seamless transportation capabilities. These program areas include vehicle automation; vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2X) communications; the Veterans Transportation Community Living Initiative (VTCLI); and Mobility Services for All Americans (MSAA). Five technology areas have emerged as potential ATTRI focus areas to improve transportation for people disabilities: wayfinding and navigation, assistive technologies, automation and robotics, data integration, and enhanced human services transportation (Fig. 3).

Fig. 3 ATTRI technology research solutions

2.1 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 in 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 system, 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.

2.2 ITS and Assistive Technologies

The broad range of wireless and sensor-based communications and information technology employed in ITS, combined with a number of other assistive technologies, can create new innovative accessible transportation solutions. This will include the traditional accessible, assistive, and adaptive devices that currently help with daily living activities and new nomadic or personal 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 such as data for caregivers and virtual attendants in different accessible communication formats: audible, tactile, and haptic. The devices used may include new innovations from the

"Internet of Things" (IoT) that are applicable to wearable technology, such as wrist bands, glasses, or clothing. These technologies will also integrate with vehicles, infrastructure, and pedestrians using dedicated short range communication (DSRC) or other communication technologies to provide V2V, V2I, and V2X communications. This will allow for connectivity throughout a trip. This area will also explore other emerging technologies within the connected vehicles, connected automation, and connected cities initiatives under the USDOT's connected vehicle research program.

2.3 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, and possibly providing connections for all travelers to existing public transportation or other transportation hubs. Applications in this area may also include collaborative robots that not only assist with daily life activities such as walking, but also work with individual travelers and human transportation services to provide related concierge services at different stages of their travel, and hence improve personal mobility across the transportation network. Machine vision, artificial intelligence, assistive robots (potentially partially humanized), and facial recognition software are included to solve a variety of travel-related issues for people with disabilities in vehicles, devices, and terminals. These technologies can create virtual caregivers/concierge services and other such applications to guide travelers and assist decision making.

2.4 Data Integration

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, 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 with accessibility needs 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 at the airport.

2.5 Enhanced Human Services Transportation

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 information and planning tools that integrate multi-modal options into a complete origin-to-destination trip. Applications in this area could 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 in order to increase flexibility and options for travelers with disabilities.

3 ATTRI Three Phase Program Plan

ATTRI is being implemented in three phases. The phases include: Exploratory and User Needs Research; Innovation, Prototype Development and Testing; and the Demonstration Phase.

Each phase will prioritize particular focus areas. These areas are as follows (Fig. 4).

Phase 1: Exploratory and User Needs Research:

- Collaboration building
- Strategic plan and roadmap
- Stakeholder engagements and user needs assessment
- State of the practice / innovation scan

Phase 2: Innovation and Prototyping:

- Accessible transportation applications selection
- Institutional and policy issues assessment
- International research coordination
- Social-economic impact

Phase 3: Demonstration:

- ATTRI joint demonstrations
- Deployment guidance
- Evaluations

Fig. 4 ATTRI three phase program plan

4 ATTRI Foundational Considerations

A number of entrepreneurs, researchers, and futurists are working to bring transformations in accessible transportation technology to assist people with disabilities and the travelers in general. The acceptance and impact of such applications will be measured by the ease of use and the simplicity, more importantly, these applications need to communicate and act in different ways to different users yet accomplish the same task of getting someone from point A to point B in different cities, towns and neighborhoods. Similar or repeatable traveler experience, irrespective of the mode of transportation or destination, can be achieved by designing interfaces and output mechanisms that interact the same way across different settings with specific foundational considerations in mind. Through outreach and stakeholder engagement activities of ATTRI, including several public workshops, a User Needs Assessment, a Technology and Innovation Scan, four (4) foundational considerations have emerged as necessary elements of accessible transportation applications to achieve a unified travel experience that meet the diverse needs of travelers with mobility, vision, hearing and cognitive disabilities. These foundational considerations are included, in the development of four (4) identified ATTRI priority application areas: (1) Smart Wayfinding and Navigation systems; (2) Pre-Trip Concierge and Virtualization; (3) Shared Use, Automated Vehicles; and (4) Safe Intersection Crossings. More specifically, any application developed under ATTRI will have considered and incorporated the foundational considerations described below.

4.1 Standard Accessible Data Platform

Data sharing and standardization is critical in developing applications which aspire to enhance the personal mobility of those with the greatest needs. Service platforms and providers, using interoperable communications, can push and pull real-time data to communicate in an efficient, succinct, adaptable, and understandable manner to meet individual user needs. Technology applications to be considered for development under the ATTRI program would like to make use of almost ubiquitous access to a wealth of real-time, situational data sources, including data specific to transportation systems, municipalities, points of interest, crowd-sourced information, and accessibility data available from different sources, including individual profiles.

4.2 Universal Design Standards

Universal design standards incorporate a philosophy that promotes the applicability of a technical solution to the needs of all user groups. An accessible Information

Communications Technology (ICT) product or service is one which can be used by all its intended users, taking into account their differing capabilities. A person's ability to use technology may be impaired due to various physical, sensory, emotional or cognitive disabilities [8]. All applications developed under the ATTRI program shall utilize universal design principles, whether developing new applications that can be used by all travelers or leveraging existing solutions and enhancing them to meet the needs of all users.

4.3 Integrated Mobile Payment

Integrated mobile payment systems typically incorporate interoperable electronic fare payment that can be utilized across various modes of transportation by all travelers including those with disabilities, at all times, and for multiple consumer purposes. The vision for a multimodal integrated payment system is to deliver, for travelers in the transportation ecosystem, the ease of use and convenience that comes from an electronic payment system and extend that ease across modes and through institutional and technical collaborations. An integrated fare payment is especially important for travelers with disabilities, particularly those with visual disabilities where they may have difficulty in distinguishing between different payment types or those with cognitive disabilities that may become confused by multiple payment requirements.

4.4 Leverage Existing Technologies

To maximize the impacts of limited ATTRI resources and respond most effectively to the needs of all users and stakeholders, any application being developed under ATTRI should leverage existing promising technologies, including but not limited to Intelligent Transportation Systems (ITS), on-demand technologies, data standards, innovative smartphone and mobile technology, and transportation and other assistive and enabling technologies, operations, and/or techniques whether currently being pursued in research, or readily available in the market. For example, can wearable technologies such as smart watches integrate accessibility needs within health monitoring applications, or provide information to remote caretakers? Can emerging wheelchair technologies such as Wii or Ogo be used in conjunction with nomadic devices to increase personal mobility vehicle options for first mile last mile mobility? In addition, partnerships with other current research or deployment efforts can help conserve resources and avoid duplicative research.

5 Moving Forward

As the second phase of the initiative begins, ATTRI is addressing a significant transportation problem in a comprehensive way. With increasing stakeholder engagements, workshops, and Request for Proposal (RFP) procurements, the ATTRI program is positioning itself to capitalize on potential large-scale opportunities. ATTRI research will improve the mobility of travelers with disabilities and provide enhanced capabilities for all travelers to reliably and safely execute independent travel. Through ATTRI research and associated new technology solutions, users in the transportation ecosystem will realize safe travel, using real-time situational awareness and information sharing [9].

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