Automated vehicle Services for People with disabilities – Involved Responsive Engineering (ASPIRE Center)

Quarterly Progress Report #2

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Topic:	Implications of Accessible Automated Vehicles and Mobility Services for People with Disabilities
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Prepared for:	University Transportation Centers Program, Office of the Assistant Secretary for Research & Technology, U.S Department of Transportation

1. Accomplishments

Aim 1: Systematic Review: We will conduct a comprehensive review of the literature to more clearly understand the current trends and implications for future travel related to accessible automated vehicles and services.

- **Specific Objectives:**

    1. Grey literature review
    2. Generate search strategy for different databases
    3. Scientific literature review

- **Major Activities:**

    1. Grey literature review: This quarter we collected and compiled **74 grey literature items** from our advisory board committee members, investigators, and colleagues. Articles found in the grey literature search addressed the following topic areas: statistics on travel needs and opportunities, satisfaction with current transportation options, desirable features of AVs, proposed guidelines and policies for AV development, and examples of incorporating the needs of people with disabilities in current AV designs or rideshare offerings.

        Most articles found in the grey literature search address the needs of people with disabilities with regard to features of autonomous vehicles. These articles comprised focus groups with individuals or representatives of stakeholder groups, interviews with experts, and development guidelines from governmental agencies [UK, San Francisco]. These publications highlight the diversity of needs amongst those with a variety of impairments. For those who use mobility aids — e.g., wheelchairs — ramps, drop floors, raised ceilings, and wheelchair securement were important features. User interface requirements varied by disability. For those with visual impairments, audio input and output, as well as tactile interfaces were desired. Those with hearing impairments, on the other hand, require visual display of information. Individuals with impaired mobility or dexterity need to be able to reach and manipulate controls. Accommodating those with cognitive impairments require simple, easy to understand interfaces. All of these modalities could be incorporated into one, flexible interface, and the AV communicating with the individual's smartphone — which may already have accessibility features tailored to that person's needs — was also discussed. All the focus group publications and expert interviews think that developers should strive for universal design — designing a single product that can be used by all.

        More details of the grey literature review will be published in an upcoming manuscript.

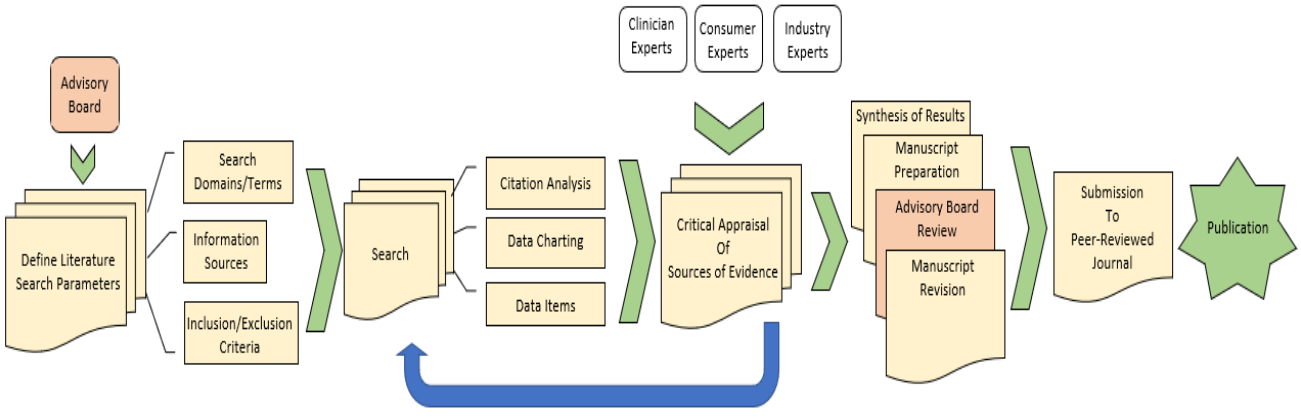
    2. Search strategy for the scientific literature: The research questions identified in our grant proposal were used to generate a search strategy for the scientific literature on automated vehicles and services for people with disabilities. This was executed in consultation with the Advisory Board and a research librarian.

        Our strategy using keywords and execution of search in PubMed resulted in **793 articles** which are currently being archived and reviewed. We are looking into other databases as well at the moment such as Ovid MEDLINE ALL, PsycINFO, and REHABDATA. The search strategy is being tailored for these databases, with consideration of available operations, indexes, and subject indexing.

3. Scientific literature review: Only those article that meet the following inclusion/exclusion criteria will be eligible to be reviewed:

    Inclusion criteria:
    I. include data from or about individuals with disabilities, caregivers, or service animals.
    II. be in the English language.
    III. be published on or after July 1990 (the year that the American's with Disabilities Act was passed)
    IV. involve accessible or inaccessible travel options, estimates or trends.
    V. must be an empirical, peer-reviewed study, a peer-reviewed literature review article, an article published in a scholarly journal.

    Exclusion criteria:
    I. anecdotal or opinion articles

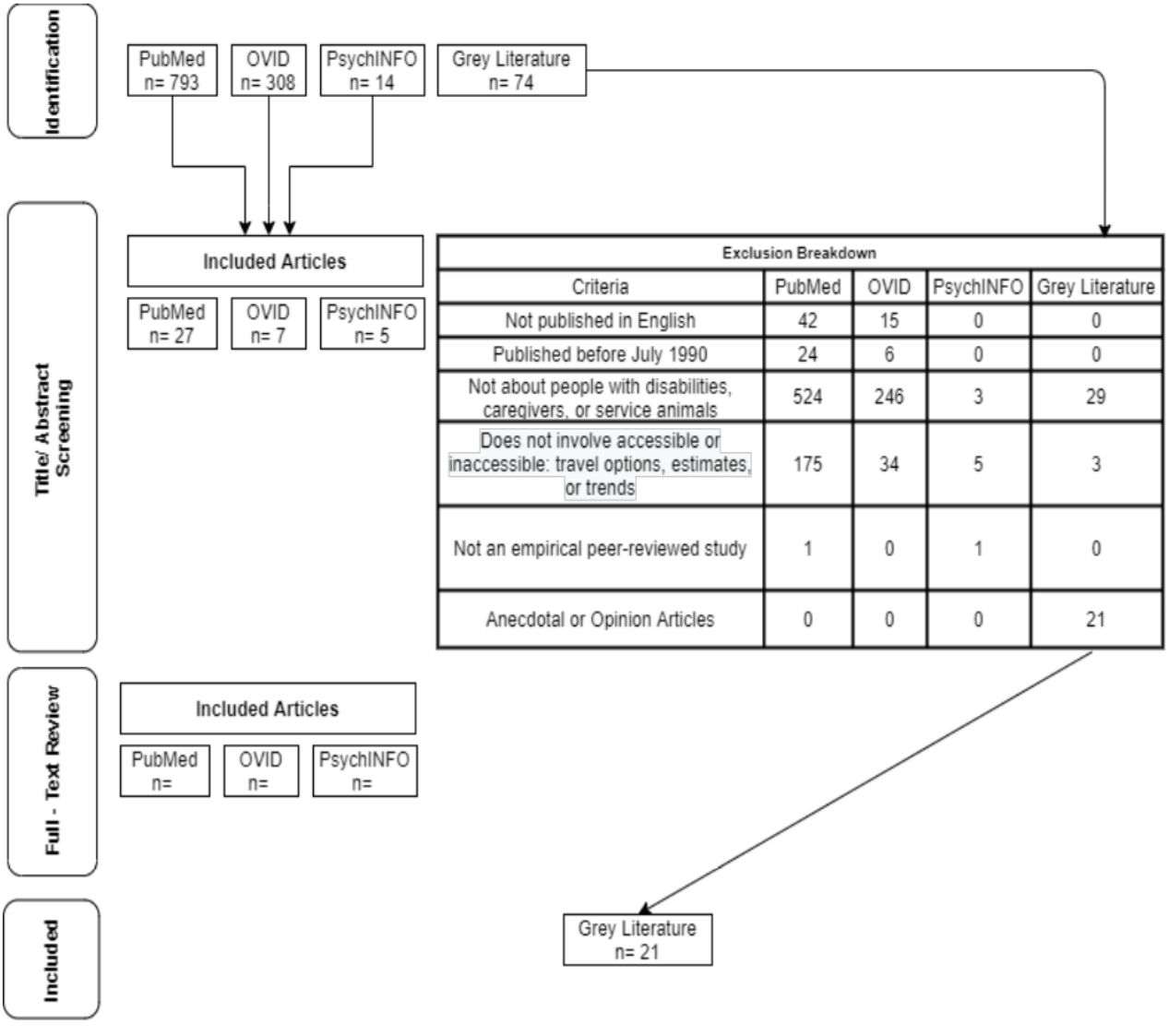


Flow Chart for Systematic Literature Search

All articles are being screened in two stages by our team: 1) title & abstract screening and 2) full-text screening. Each article is screened independently by two members and a tie breaker is assigned in case of conflicts. Furthermore, the references cited in the included full-text articles and in previously published reviews on adjacent topics will be screened for potential inclusion in this review.

To date, 39 articles have passed the first level of screening and are further being reviewed. External reviewers from the advisory board were also given the opportunity to participate in the full text manuscript review to extract essential data (key study details, factors that determine evidence quality, and summary of findings generated) out of the articles that pass the first and second level of the review. Each publication will be scored by two trained investigators independently using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology. GRADE is a transparent framework for developing and presenting summaries of evidence and provides a systematic approach for making clinical practice recommendations.

A Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow Diagram was developed to display the inclusion and exclusion of articles at each stage of the review. We will continue to update the below flowchart in future reports to show the status of the systematic review.



PRISMA Flow Diagram

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Aim 2: **Understand the needs of Users and Providers:** We will conduct surveys, focus groups, and journey mapping of stakeholders, including individuals with disabilities, their travel companions and/or caregivers, designers, medical providers, and mobility service experts (e.g., vehicle manufacturers and modifiers, as well as adaptive driving training instructors). The survey will be refined using pilot surveys, focus groups and journey mapping and then distributed broadly to all key stakeholders.

- **Specific Objectives:**

  1. Institutional Review Board (IRB) compliance

- **Major Activities:**

  Currently two IRB protocols are under development at Pitt:

  - ❖ STUDY20090111- ASPIRE Voice of Consumer-Provider (Focus Group)
  - ❖ STUDY20120052- ASPIRE VoC-VoP Survey

  We anticipate IRB approval for the Focus Group before next quarter. Research gaps identified in Aim 1 will be used in the iterative development of the Voice of the Consumer and Provider surveys for Aim 2. In preparation for STUDY20120052, survey questions are being discussed and designed using REDCap which is a browser-based, metadata-driven EDC software and workflow methodology for designing clinical and translational research databases. The survey will be developed with branching logic so that questions are posed to the appropriate respondent depending on their characteristics (i.e., person with a disability, travel companion, provider).

2. Changes/Problems

a. Actual Problems or delays and actions to resolve them

Nothing to Report.

b. Anticipated Problems/Issues

Nothing to Report.

3. Collaborations

We have been continuously engaging with advisory board members in Aim 1 activities during the quarter. We have also collaborated with *Merlin Mobility, Inc., and Easterseals* on U.S. DOT Inclusive Design Challenge application and other grant submissions such as NIDILRR Field Initiated Research Program and NIDILRR Small Business Innovation Research grant. Over the quarter, Dr. Cooper has served as a panelist and participated in the following panel discussions:

- Round-table discussion with Finch Fulton, the Deputy Assistant Secretary of Transportation Policy for the U.S. DOT.
- Pittsburgh Technology Council- “Business As Usual”
- Disability News Report- “The Future of Self Driving Cars for People with Disabilities” https://disabilitynewsreport.tv/reports/the-future-of-self-driving-cars-for-people-with-disabilities/
- American Public Transportation Association (APTA)- "Update on FTA Transit Automation Research Initiatives"

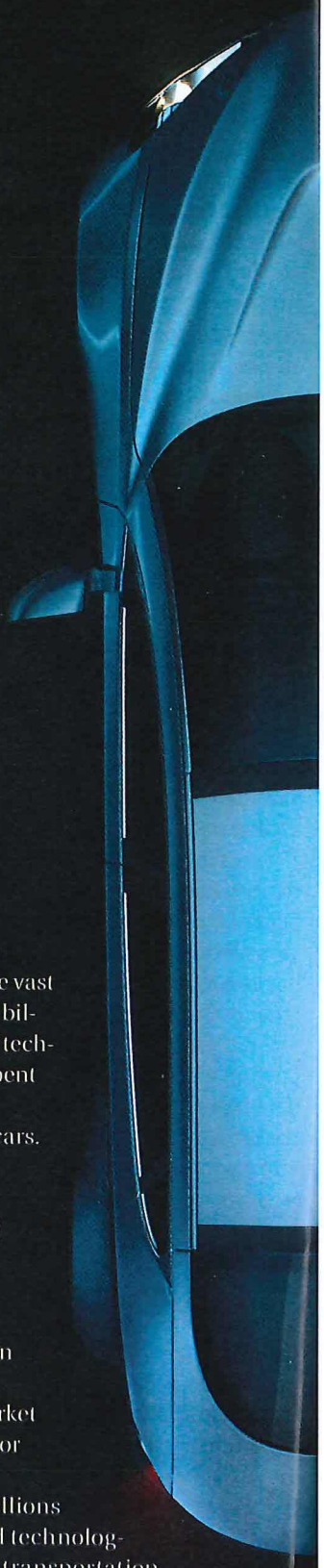
4. **Outcomes/Impact**
   Drs. Cooper and Dicianno submitted an article on “Accessible AV Technology” which will be featured in the PN Magazine’s Feb 2021 issue. (Please see appendix)

5. **Education and Workforce Development**
   In this quarter, we continued to engage PhD students in the literature review activities (Aim 1).

6. **Performance metrics**
   We are currently working on a manuscript. The initial draft of the manuscript will be reviewed by the Advisory Board. It will be revised and then submitted to a high impact journal that covers the most important advances in the field of Accessible Autonomous Vehicles and Transportation Systems over the past few years, and we expect that it will shape the field and be highly cited.

APPENDIX

Where To?



Autonomous vehicles are still in various stages of development, but they hold great promise to help people with disabilities travel faster, safer and more easily.

by Rory A. Cooper, PhD, & Brad Dicianno, MD

Throughout much of the United States, the capacity to drive opens the door to greater participation in life, job opportunities, access to health care, education and a general sense of freedom.

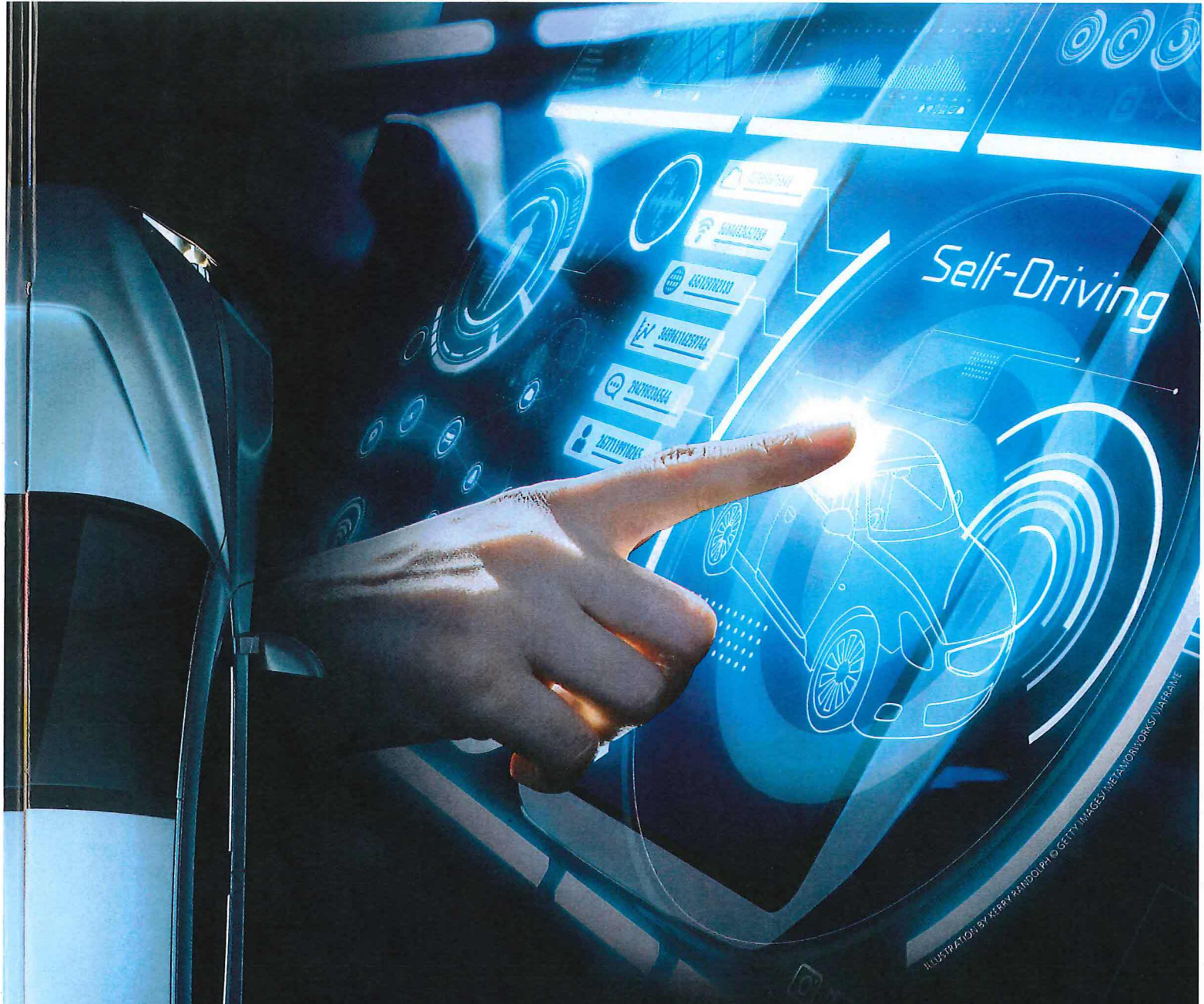
However, those same opportunities can be really restricted for people with disabilities such as spinal-cord injury and disease (SCI/D). There are some who don't drive, don't have easy access to a ride or live in a metropolitan area with limited public transportation options.

Additionally, with the ever-growing retirement of the baby boomer generation, who largely want to "age in place," there's an increasing need for accessible and enabling personal transportation.

The transportation industry is in the middle of one of its largest transformations, with unprecedented investment and advancements in electric and autonomous vehicle (AV) technologies.

Since 2009, the vast majority of the $14 billion invested in AV technology has been spent in pursuit of mass market driverless cars. These efforts have produced significant advances, but the technological, psychological and regulatory constraints that remain will likely make widespread AV market adoption a decade or more away.

Despite the billions invested and rapid technological advances, the transportation options for older adults and persons with disabilities remains largely the same.



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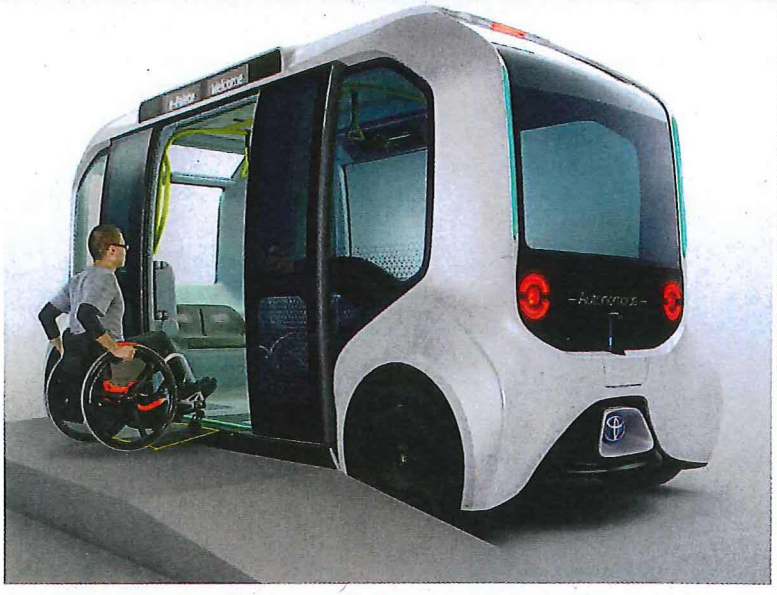
Incorporating Accessibility

A 2015 report from the National Council on Disability titled *Self-Driving Cars: Mapping Access to a Technology Revolution* explored the "emerging revolution in automobile technology and the promise it holds for people with disabilities, as well as the obstacles the disability community faces to realize that promise." It makes several key recommendations:

- Research and development of AVs and their components should include a requirement that demonstrates that any resulting products incorporate accessibility of people with diverse disabilities, and these technologies should be required to comply with Section 508 of the Rehabilitation Act of 1973.
- Guidelines are needed for how people with disabilities can safely interact with and use AVs.
- All types of common and public use AVs must be fully accessible.



COURTESY OF HUMAN ENGINEERING RESEARCH LABORATORIES

Toyota is among the vehicle manufacturers trying to develop and test autonomous vehicles.

The Human Engineering Research Laboratories (HERL) at the University of Pittsburgh and the U.S. Department of Veterans Affairs was recently funded by the Department of Transportation to create the Automated vehicle Service for People with disabilities – Involved Responsive Engineering (ASPIRE) Center.

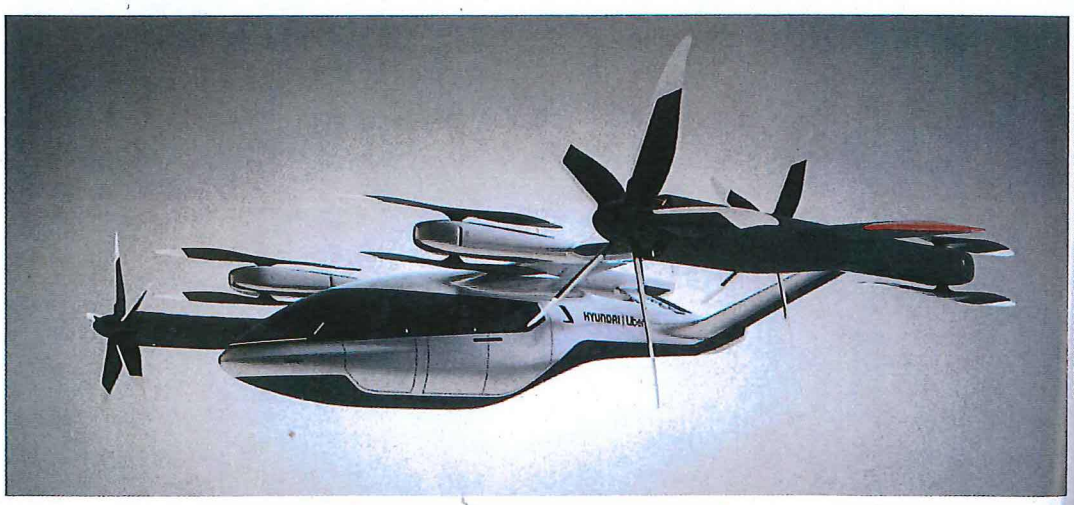
The ASPIRE Center is investigating the implications of accessible automated vehicles and mobility services for people with disabilities and their caregivers.

A 2017 survey from the Bureau of Transportation Statistics found that 6 million people with a disability have difficulty getting the transportation they need. There have been no overarching federal laws specifically governing AVs, but the National Highway Traffic Safety Administration released federal guidance on the issue in 2019.

The Society of Automotive Engineers (SAE) international standard J3016 provides a common taxonomy and definitions for automated driving to simplify communication and facilitate collaboration within technical and policy domains.

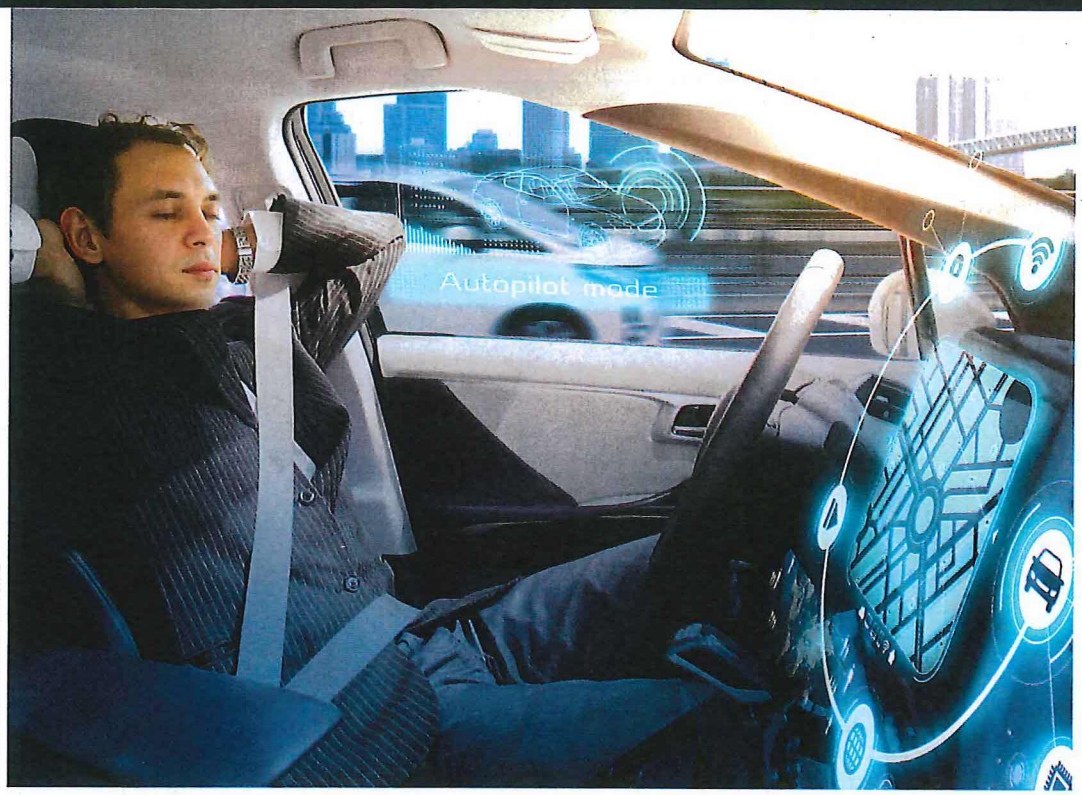
The SAE defines more than a dozen key terms and provides full descriptions and examples for each level of autonomy. Unfortunately, it doesn't address usability and accessibility for people with disabilities.

Ford, Toyota, Hyundai, Mercedes-Benz, Tesla, Google and Uber, among others, are developing AVs that are either currently being tested on American roadways or will be within the next five years.



COURTESY OF HUMAN ENGINEERING RESEARCH LABORATORIES

Hyundai plans to produce and deploy air vehicles in collaboration with Uber through a ground and aerial rideshare network.



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Self-driving personal vehicles could potentially provide a hands-free autopilot driving mode.

Of course, not all AVs are intended for roads. Hyundai is working with the city of Los Angeles to introduce accessible flying AVs as an urban air mobility solution. Hyundai has adopted a NASA strategy by publicly releasing its design concepts to inspire people to use them to innovate emerging engineering technologies.

Hyundai plans to produce and deploy air vehicles in collaboration with Uber through a ground and aerial rideshare network. A collaborative infrastructure is being developed to support this on-demand AV transportation system.

Eliminating Barriers

Different levels of automation pose distinct possibilities and challenges for people with disabilities. Therefore, accessibility research needs to be driven by and for people with disabilities to assure that their needs and preferences are incorporated.

As noted by the National Council on Disability's 2017 report, *Self-Driving Cars: The Impact on People with Disabilities*, "The disability community knows better than any other how being involved in the planning from day one is critical to a successfully accessible product, regardless of how many years in the future it lies."

The report found that mitigating transportation-related barriers for people with disabilities would enable new employment opportunities for approximately 2 million

This self-driving vehicle is used for test drives conducted by Uber Technologies Inc.

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people with disabilities and save $19 billion annually in health care expenditures from missed medical appointments alone.

Most people with disabilities have only three viable transportation options:

- Operate a personal vehicle
- Rely on the services of others
- Use accessible public transportation

For people with disabilities who don't live in urban areas, owning and operating a personal vehicle or relying on friends and family are the only realistic options. In multiple studies to identify unmet needs of individuals with disabilities receiving community-based services, transportation has been consistently highlighted as an issue.

HERL investigators surveyed the opinions of more than 1,000 users of mobility devices and assistive technology to identify a research and development road map. The survey focused on advancements in mobility-related assistive technologies and asked about the importance of developing futuristic technologies related to transportation.

This work indicates that advancements in technologies related to transportation are very important to individuals with disabilities and represent a significant unmet need. More than 60% of respondents rated the importance of technology in meeting their personal mobility needs as "critical," and over 40% thought that traveling freely was also "critical."

Some survey participants provided additional comments, with approximately 12% mentioning transportation as being critical and "self-driving" vehicles being included in nearly 50% of those comments.

Making An Impact

There are risks and challenges associated with both AVs and accessible vehicles.

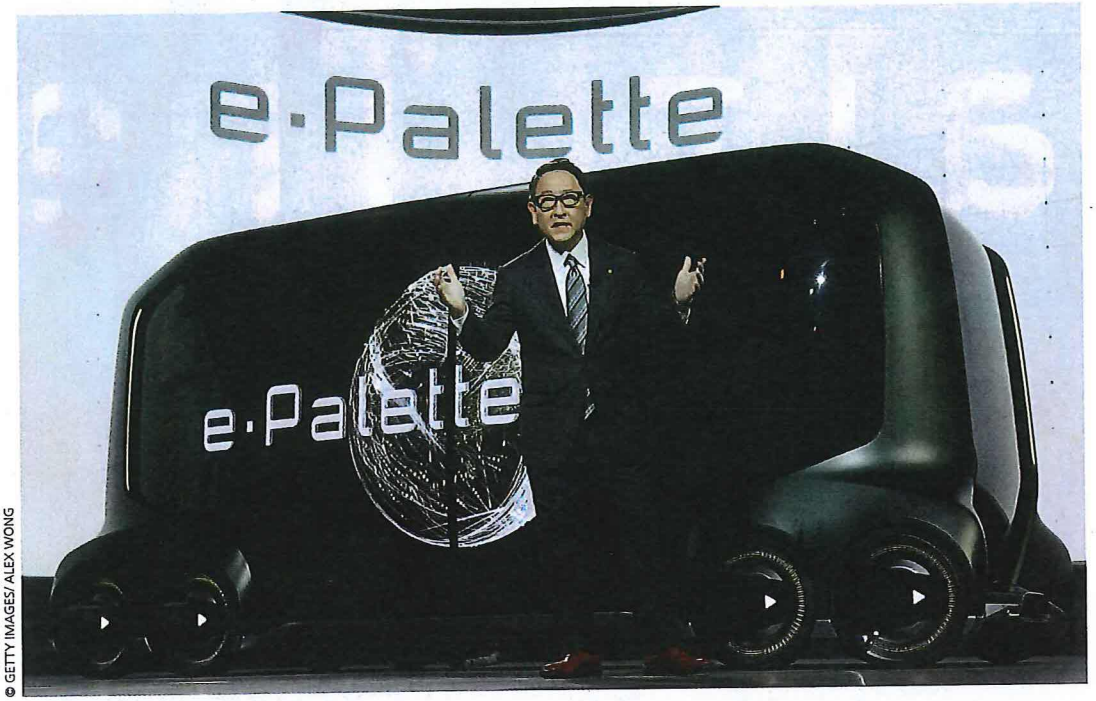
The experiences gathered through the University of Pittsburgh Medical Center's Center for Assistive Technology show that current levels of autonomy available in commercially available vehicles can have an impact.

For example, older drivers or "insecure drivers" can (re)gain the safety and confidence to drive, and driving instructions can improve through quantitative data. Such features as rear collision/obstacle avoidance, corrective steering and blind-spot warnings can make all drivers safer and make driving possible for others.

The Merlin Co-pilot is an AV technology that is intended to mitigate the risks and challenges by providing capabilities compatible with newer accessible vehicles to make them more autonomous. The system is integrated into the vehicle to access vehicle functions and features, including braking, signaling and others that are essential for safe vehicle control. It adds autonomous features to people's existing accessible vehicles.

This is particularly important because accessible vehicle modifications can be expensive, ranging from as low as $1,500 to as high as $100,000, excluding the cost of the vehicle. People tend to keep

To be successful, automated vehicle technology needs extreme reliability, especially if it's the only means a person has to drive safely.



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Toyota Motor Corp. President Akio Toyoda speaks in front of the e-Palette Concept Vehicle, a fully autonomous, battery-electric vehicle, during a press event for the consumer electronics trade show known as CES in Las Vegas in 2018.

their modified accessible vehicles as long as it is feasible. For people who use adaptive vehicles to eventually adopt AVs, the technology has to be available, affordable and compatible with vehicle access needs.

It's likely to be over a decade before this is possible, and even people with disabilities who buy an accessible vehicle today will probably be using that same vehicle even as other customers start to transition to AVs.

Moving Forward

Most AVs are based on electric vehicle chassis. Some electric vehicles that could be accessible to people present challenges because they don't include, for example, traditional handholds used to help transfer in/out of the vehicle.

For people who use their wheelchairs as seats in motor vehicles, the ability to use wheelchair tie-downs and occupant restraints needs to be considered. By upgrading existing modified vans, this barrier could be lowered at least until manufacturers start producing purpose-built vehicles.

To be successful, AV technology needs extreme reliability, especially if it's the only means a person has to drive safely. Cost is also a notable issue. Devices and systems that are too costly will essentially be inaccessible to many people with disabilities. Moreover, the need to buy a new vehicle is a significant hurdle for many people with disabilities.

Currently, accessible personal electric vehicles, the likely future for autonomous vehicles, are in various stages of research and development. Toyota Motor Corp. plans to deploy an accessible autonomous transportation system for this summer's Olympic and Paralympic Games in Tokyo.

The system will include a wide range of vehicles to travel within and between venues. This should prove an important milestone in accessible AV progress and provide important information for moving forward.

Autonomous vehicle technologies have the potential to drastically improve access for people with SCI/D, as well as for people who have vision, hearing, intellectual and developmental disabilities. People with disabilities need to be engaged in and help guide the development of AV technologies.

For more information on HERL, visit herl.pitt.edu.

Rory A. Cooper, PhD, is the founder and director of HERL, while Brad Dicianno, MD, serves as the organization's medical director and chief operating officer. ■