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

Quarterly Progress Report #9

Grant Number:	69A3552047140
Topic:	Implications of Accessible Automated Vehicles and Mobility Services for People with Disabilities
Center Director **Center Co-Director**	Rory A. Cooper, PhD Brad E. Dicianno, MD, MS
Phone and Email:	412-822-3700 rcooper@pitt.edu
Primary Site:	University of Pittsburgh
Partner Universities:	Uniformed Services University of Health Sciences The Catholic University of America
Report Date:	10/26/2022
Report Period:	7/1-9/30/2022
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 understand the current trends and implications more clearly for future travel related to accessible automated vehicles and services.

- **Specific Objectives and Major Activities:**

Nothing to report this quarter as we have completed Aim 1 as mentioned in previous reports. Please refer to the below-mentioned manuscript publication:
https://doi.org/10.1016/j.neulet.2021.136103

Dicianno, Brad E., Sivashankar Sivakanthan, S. Andrea Sundaram, Shantanu Satpute, Hailee Kulich, Elizabeth Powers, Nikitha Deepak, Rebecca Russell, Rosemarie Cooper, and Rory A. Cooper. "Systematic Review: Automated Vehicles and Services for People with Disabilities." Neuroscience Letters (2021): 136103.

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. Wrap up "Journey Mapping"
  2. Wrap up "AV Focus Groups"
  3. Continue to recruit and enroll research participants for the VOC-VOP survey

- **Major Activities:**

  Journey Mapping & AV Focus Groups- Completed study protocol per approved University of Pittsburgh IRB# STUDY20090111. Manuscripts have been submitted to journals as described in the performance metrics section below.

  Journey Mapping: **N= 20 participants**
  AV Focus Groups: **N= 21 participants**

  Survey- **N= 1129 (VOC); N=49 (VOP)**. Study recruitment efforts and pilot data analysis are ongoing. Additional outreach activities were planned and implemented.

  Study title: Automated vehicle Services for People with disabilities – Involved Responsive Engineering (ASPIRE Center): Voice of Consumer-Provider survey
  IRB #: STUDY20120052

  Voice of Consumer (VOC): Individuals with disabilities/older adults, travel partners like caregivers or spouse; Voice of Provider (VOP): Transportation Provider, Expert or Designer

  Survey links: Automated vehicle Services for People with disabilities – Involved Responsive Engineering (ASPIRE Center) | Human Engineering Research Laboratories | University of Pittsburgh

Aim 3: <u>Data synthesis, extrapolation, analysis, and modeling</u>: We will synthesize the data obtained to understand the current and future needs of potential stakeholders of accessible automated transportation and services. This will involve presenting summary survey findings, extrapolating findings to the greater population of potential automated vehicle users, combining our data with publicly available datasets to understand factors that influence travel, displaying clusters of users based on their characteristics and needs and ideation and development of solid models that illustrate key features and parameters for implementing automated vehicles and mobility services.

- **Major Activities:**

'Journey Mapping' data analysis:

Data will be published in the 'Transportation Research Record'. The manuscript was submitted on 8/19/2022 and is currently under review with the TRR Editorial Board for assessment.

Abstract:

The purpose of the study was to understand travel considerations and identify barriers for people with disabilities (PWDs) for each travel stage, from considering a trip through arriving at the final destination for their current modes of transportation. Twenty PWDs including those with physical (n=10), vision (n=4), hearing (n=1), cognitive (n=4), and combined physical/visual (n=4) impairments participated in a semi-structured one-on-one interview to identify the transportation issues. Descriptive statistics were used for demographic information, and a qualitative content analysis was used to analyze the transcribed interviews and extract themes. Themes were further organized by the modes of transportation used. The top four themes in considering and planning a trip phase were: 3rd party assistance availability (private vehicle, public transportation, and paratransit), finding an accessible or suitable parking space (private vehicle), access to a service location (public transportation and paratransit), and transportation schedule (public transportation and paratransit). The top four travel barriers in locating, entering, riding, and exiting the transportation and arriving at the destination were: ingress/egress to the vehicle (private vehicle and public transportation), concerns with wheelchair securement (public transportation and paratransit) and requiring 3rd party assistance (private vehicle and public transportation), and accessibility to service location (public transportation). The study suggests that to mitigate travel considerations and barriers for PWDs, not only vehicle-specific barriers but also infrastructure issues should be addressed simultaneously. We expect that the findings will provide insight into the design and development of future forms of transportation, such as autonomous vehicles.

Keywords: User needs, Content analysis, Individuals with disabilities, Structured interview, Transportation use, Travel difficulties,

'AV Focus Group' data analysis:

Data will be published in the 'Disability and Rehabilitation: Assistive Technology' journal. The manuscript was submitted on 10/17/2022 and is currently under review.

Abstract:

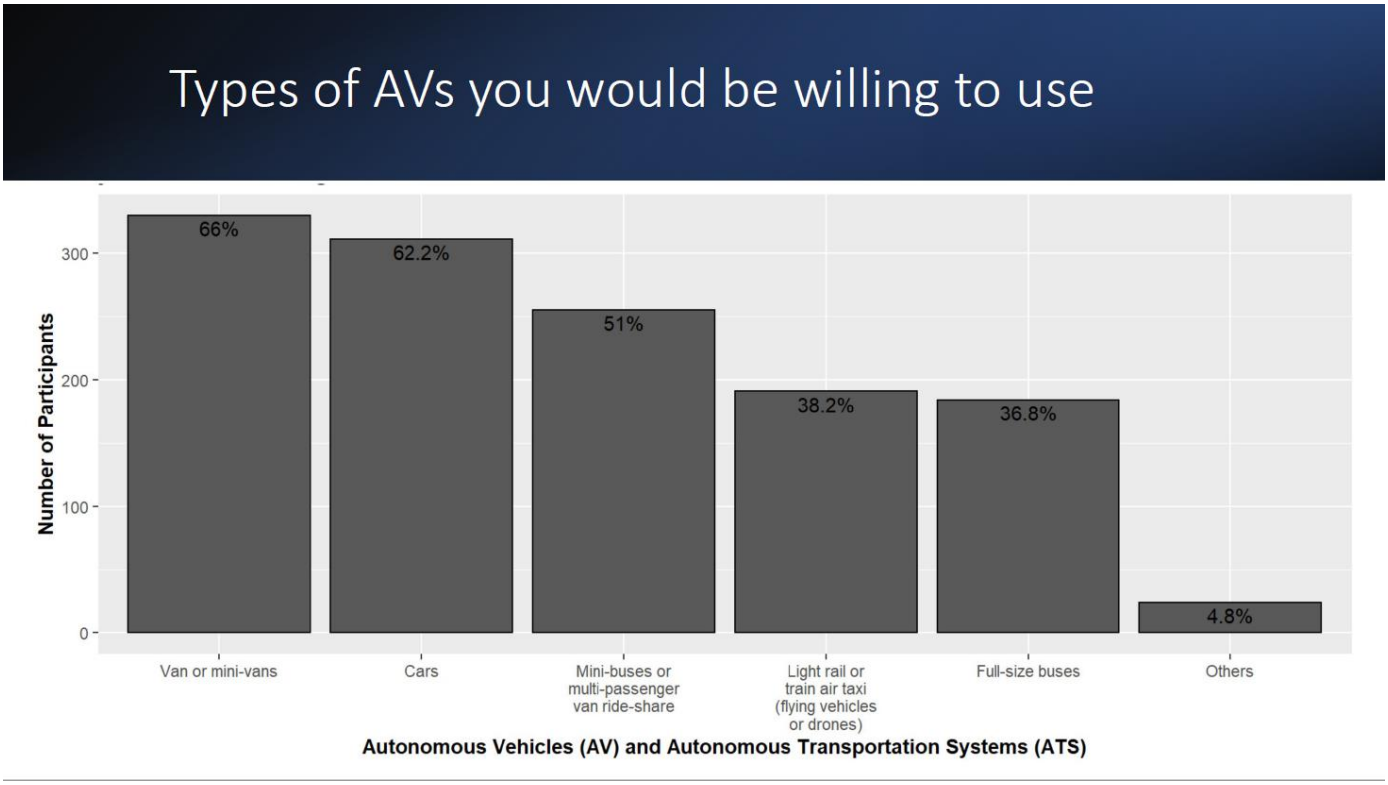
Purpose: Existing automated vehicle transportation guidelines and regulations have minimal guidance to address the specific needs of people with disabilities. Accessibility should be at the forefront to increase autonomy and independence for people with disabilities. The purpose of this research is to better understand potential facilitators and barriers to using accessible autonomous transportation. Methods: Focus groups were conducted with key stakeholders derived from people with disabilities (n = 5), travel companions/

caregivers (n =5), and transportation experts or designers (n = 11). Results: The themes include describing the stakeholder perceptions across all three groups by identified themes: autonomous vehicle assistive technology, autonomy vs automation, cost, infrastructure, safety & liability, design challenges, and potential impact. Conclusion: Specific gaps and needs were identified regarding barriers and facilitators for transportation accessibility and evidence-based guidance. These specific gaps can help to formulate design criteria for the communication between, the interior and exterior of accessible autonomous vehicles.

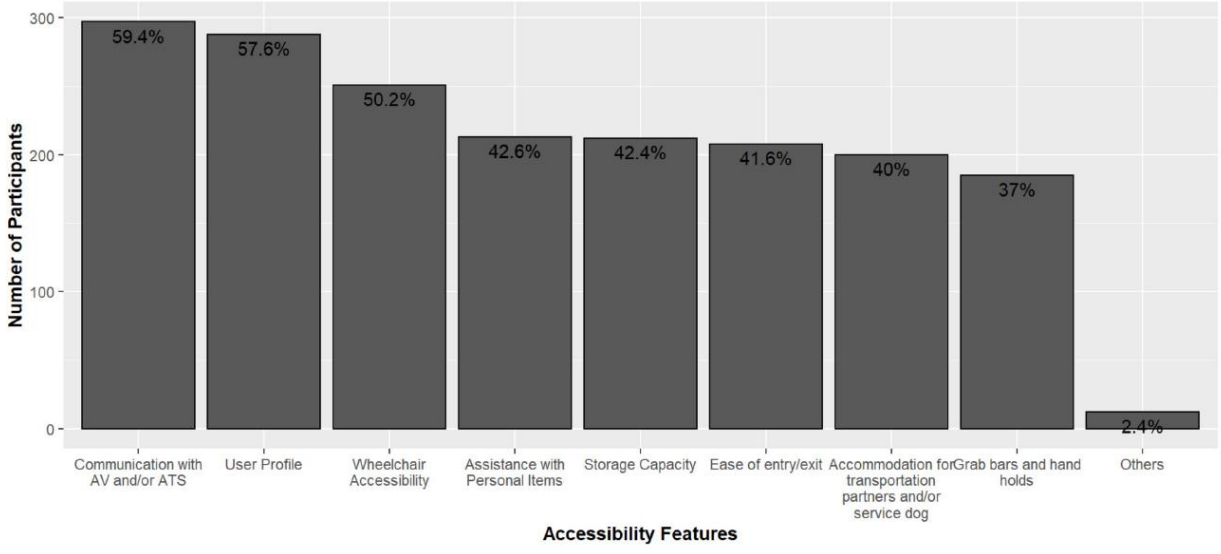
Voice of the Consumer Pilot Data Analysis

Data from the first 500 survey respondents are currently being analyzed and we plan to publish this pilot analysis. This will be followed by a full paper analysis to find clusters of participants with similar responses to create design criteria for AV features and services. Below are some of the results on the following topics:

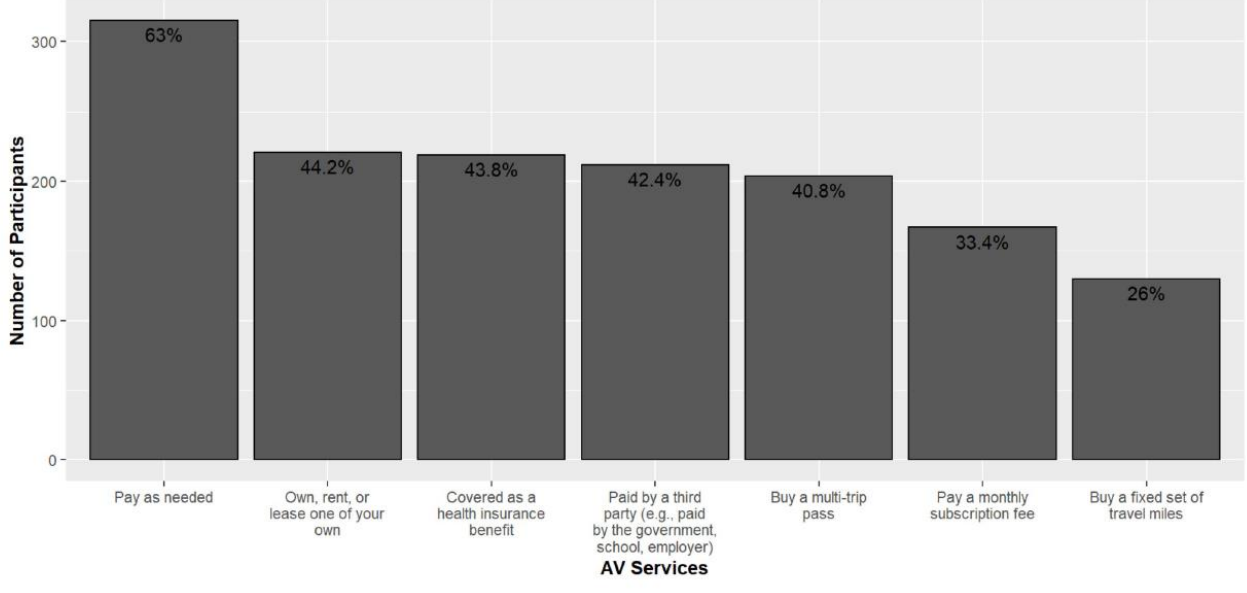
- Preference of types of AVs/ ATS (e.g., mini-vans, cars, etc.)
- Required accessibility features of AV and/or ATS
- AV services (Business models) (e.g., own, rent or lease, monthly subscription, 3rd party payer, etc.)
- Preference for automated driver assist features
- Other important socio-demographics info



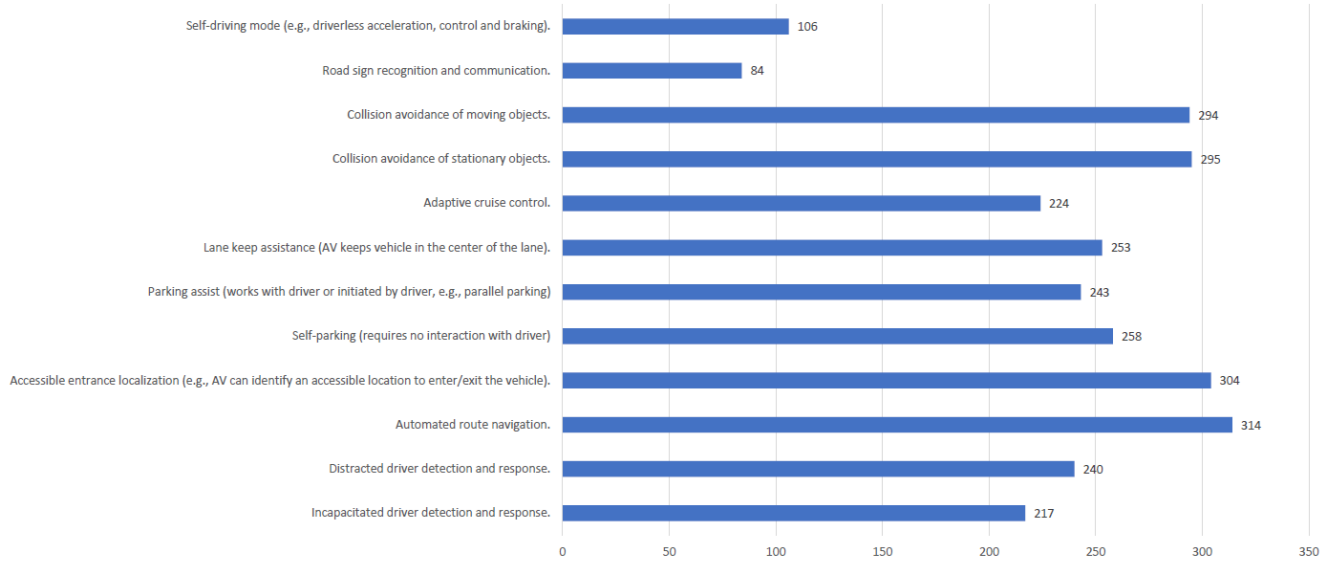
Accessibility Features



AV Services



AV Features



Demographics

Age	Ambulatory (%)	Hearing (%)	Independent living difficulty (%)	Self-Care Difficulty (%)	Vision (%)
18-24	3.79%	1.69%	5.80%	4.80%	5.49%
25-34	11.99%	23.73%	10.14%	12.80%	16.48%
35-44	18.30%	22.03%	17.39%	21.60%	18.68%
45-54	14.51%	10.17%	21.01%	20.00%	18.68%
55-64	23.03%	11.86%	28.26%	20.00%	18.68%
65-74	21.14%	18.64%	13.77%	15.20%	19.78%
75+	7.26%	10.17%	3.62%	5.60%	2.20%
Under 18	0.00%	1.69%	0.72%	0.00%	0.00%

Time Living with Disability	Ambulatory (%)	Hearing (%)	Independent living difficulty (%)	Self-Care Difficulty (%)	Vision (%)
1-5	11.04%	23.73%	7.97%	8.00%	19.78%
11-15	13.56%	11.86%	8.70%	12.00%	7.69%
16-20	10.09%	8.47%	11.59%	8.80%	4.40%
21-25	7.57%	3.39%	17.39%	12.80%	6.59%
25+	39.43%	28.81%	42.03%	40.00%	41.76%
6-10	17.03%	22.03%	12.32%	17.60%	17.58%
Less than 1 year	0.95%	1.69%	0.00%	0.80%	2.20%

Race	Ambulatory (%)	Hearing (%)	Independent living difficulty (%)	Self-Care Difficulty (%)	Vision (%)
American Indian or Alaskan Native	0.00%	3.39%	2.17%	0.00%	3.30%
Asian	3.15%	1.69%	2.17%	1.60%	4.40%
Black or African American	11.67%	8.47%	11.59%	9.60%	13.19%
Native Hawaiian or other Pacific Islander	0.32%	1.69%	0.72%	2.40%	1.10%
Prefer not to answer	7.26%	5.08%	0.72%	5.60%	3.30%
Two or more races	2.52%	5.08%	75.36%	3.20%	67.03%
White or Caucasian	74.76%	72.88%	0.00%	76.80%	0.00%

Gender	Ambulatory (%)	Hearing (%)	Independent living difficulty (%)	Self-Care Difficulty (%)	Vision (%)
Female	39.75%	52.54%	59.42%	50.40%	47.25%
Male	55.21%	42.37%	39.13%	44.80%	47.25%
Non-binary/third gender	2.21%	3.39%	0.72%	3.20%	2.20%
Prefer not to answer	1.89%	1.69%	1.45%	1.60%	2.20%
Transgender: Female to Male	0.63%	0.00%	0.00%	0.00%	0.00%
Transgender: Male to Female	0.00%	0.00%	0.00%	0.00%	1.10%

New sub-project: Wheelchair Accessible Autonomous Vehicle Concept

We are developing a holistic systems approach for powered wheelchairs and accessible vehicle design which will drastically lower costs and revolutionize this accessible vehicle industry. Many auxiliary factors, such as vehicle dimensions, ramp access, and a docking station were considered when designing the Simplified Accessible Vehicle and Robotic (SAVER) Wheelchair. To determine feasible dimensions for the chair, the inside of a Chrysler Pacifica was scanned, and its dimensions were displayed using Solidworks as shown in the previous quarterly report. Knowing the layout of the van allowed for the creation of a rough Solidworks drawing of the chair and determined the dimensions it would have to take for a successful ingress and egress. The final dimensions were used to determine important design features of the chair, such as the need for a recline feature or the position of the drive wheels.

In addition to vehicle dimensions, ramp length also needed to be determined. The appropriate ramp length was also based on the Solidworks van sketch, and multiple length options were considered through analysis of the chair concept and how it related to the van structure. The inside of the van also must have a docking station to be in accordance with RESNA standards; a docking station secures the wheelchair to ensure it is just as safe as the permanently mounted seats in the car. The addition of a docking station means that the user must be able to maneuver the SAVER chair inside the van to successfully dock the chair, which adds a level of complexity to the SAVER design.

Figure 1- Driving Position

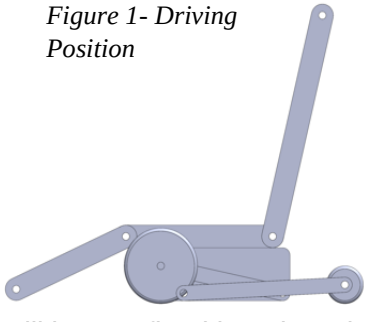
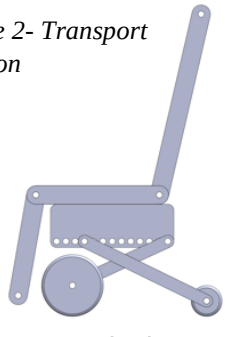


Figure 2- Transport Position

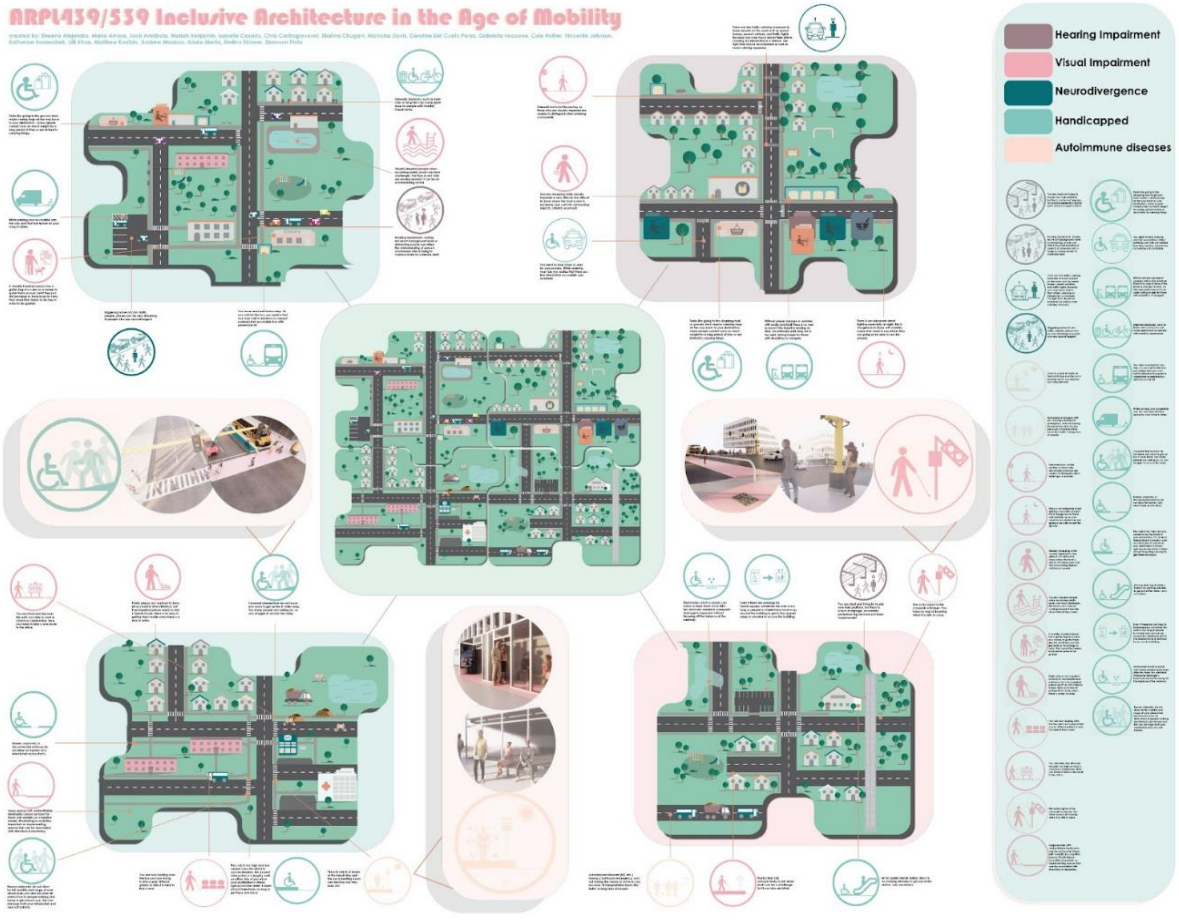


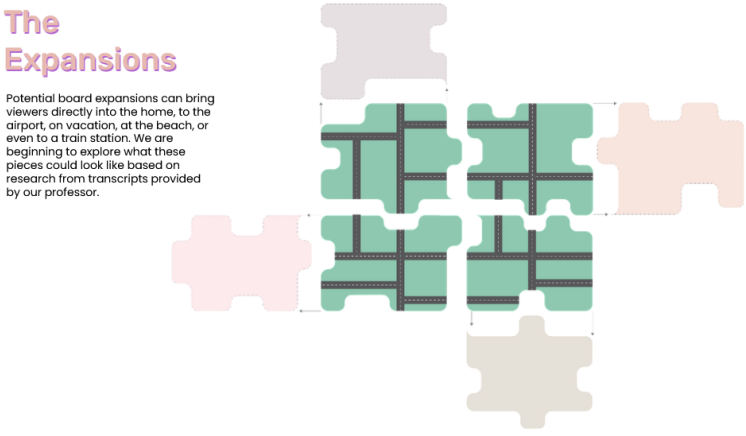
The SAVER design went through many concepts before a tentative final design was reached. The final SAVER design utilizes a series of actuators that change the angles of the chair legs relative to the ground. This creates a tilt function, which is common in many electric-powered wheelchairs. However, most commercial electric-powered wheelchairs use heavy machinery within the seat to induce tilt, while the SAVER chair will do it solely through changing leg angles, which drastically reduces weight. The legs will have a fixed length and collapse towards the seat of the wheelchair as it ingresses into the van, making the wheelchair shorter as shown in Figures 1 and 2. Reducing the height of the chair in addition to tilt and recline features will allow the chair to smoothly pass through the van door threshold.

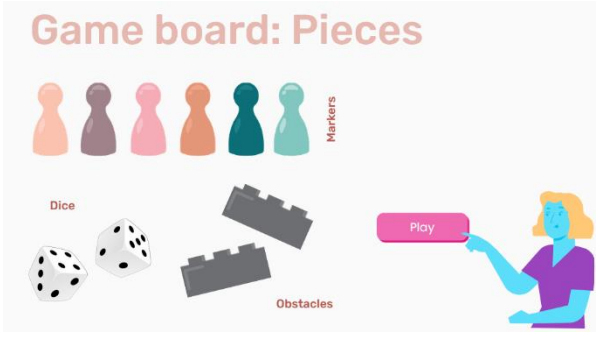
CUA Design team updates:

This quarter, our partners from the School of Architecture & Planning (CUA) worked on:

- **Design studio and Board Game:** Fall semester class on “Inclusive Architecture in the Age of Automated Mobility” (in the curriculum of the School of Architecture and Planning, the Catholic University of America, D.C. Taught by ASPIRE design team Principal Investigator, Lavinia Fici Pasquina, Faculty.) has begun and below are some graphical illustrations (More graphics available in the appendix section) from student presentations that show accessibility challenges with transportation systems and possible architectural solutions to a number of specific system problems for people with varying disabilities in a community setting.
- Design studio work includes a mobility journey board game, “Destinations & Mobility”. The board game will be created in both web and physical format to distribute as an educational tool for therapy students (primarily occupational therapy and vocational rehabilitation counseling), architectural students, and civil and transportation system engineers. The game will help to teach students and practitioners about barriers and facilitators for accessible transportation to include AV and AT. This will transform education and practice to grow a community that is knowledgeable about the needs and advances in accessible transportation.
- Graphical elements to communicate environmental and personal conditions relevant to the mobility journey. “Visual standards” such as graphical symbols (e.g., “icons”)
- Designed a mobility journey solution. For example, a multipurpose transportation node accommodating AVs the architecture of which facilitates mobility journeys of people with or without disabilities.







2. Changes/Problems

a. Actual Problems or delays and actions to resolve them

Survey completion rates have been one of the challenges and we have encouraged participants to complete the survey in person, when possible, at recruitment events.

b. Anticipated Problems/Issues

Nothing to Report.

3. Collaborations

This quarter, we have continued to engage advisory board members in project activities such as survey dissemination, manuscript review, etc. Another DoT-ASPIRE Center Advisory Board meeting was held on Oct 4, 2022, and we will continue to hold these bi-monthly meetings.

4. Education and Workforce Development

In this quarter, we continued to engage Ph.D. and Postdoctoral students in survey outreach activities and data analysis. The summer interns engaged with ASPIRE Center completed their assigned projects and presented posters, papers, and elevator pitches during the HERL Open House held on Jul 28th, 2022.

Student papers:

1) Modeling a wheelchair-accessible van using 3D scanning technology
2) Personal vehicle docking system for a power wheelchair
3) Simplified Accessible Vehicle and Robotic (SAVER) Wheelchair Initial Research and Development

Over the quarter, Dr. Cooper and team have presented/conducted outreach activities at the below events:

- State of the Science Symposium- September 28, Bethesda, Maryland
- REHACARE- September 14-17, Dusseldorf, Germany
- Veterans Resources Fair- September 16th, Pittsburgh, PA
- PVA Healthcare Summit- August 29-31, Dallas, Texas
- Ryan Shazier Street Fair Event- August 21st, Pittsburgh, PA
- Department of Defense Warrior Games-August 19-23, Orlando, Florida
- 1st Annual Disability Pride Pittsburgh - July 23rd, Pittsburgh, PA
- National Veteran Wheelchair Games 2022 – July 5th to July 9th Tempe, AZ

5. Performance metrics

The Journey Mapping manuscript, *"Understanding Travel Considerations and Barriers for People with Disabilities to Using Current Mode of Transportation through Journey Mapping"* has been submitted to 'Transportation Research Record' and is currently under review.

Focus Group manuscript, *"Accessible Autonomous Transportation and Services: A Focus Group Study"* has been submitted to 'Disability and Rehabilitation: Assistive Technology' and is currently under review.

Other News/Media:

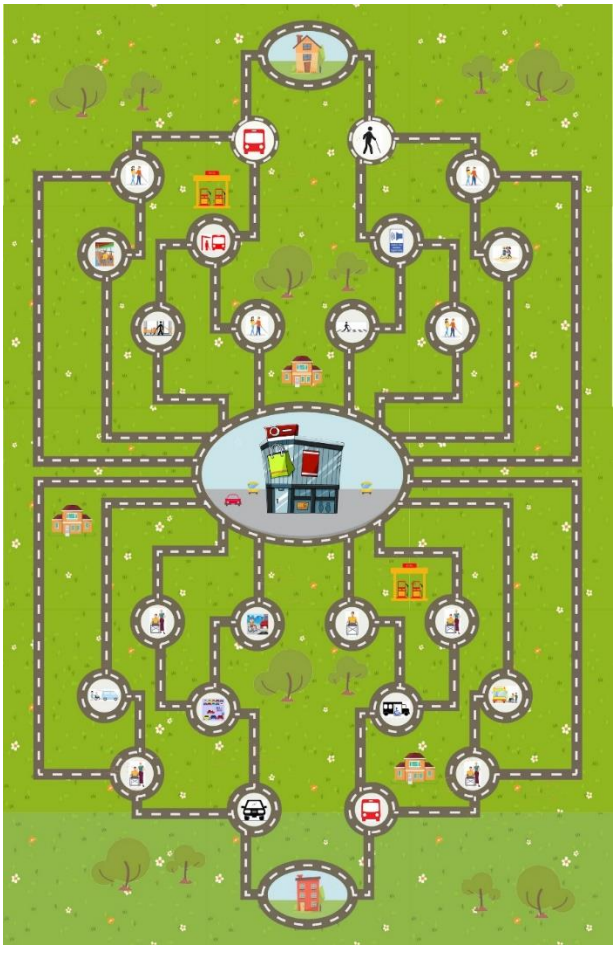
October HERL quarterly- The Oct 2022 issue of the Human Engineering Research Labs (HERL) features articles about our Department of Transportation - University Transportation Center, recent patents, job openings, research-development study recruitment, and much more!

Appendix

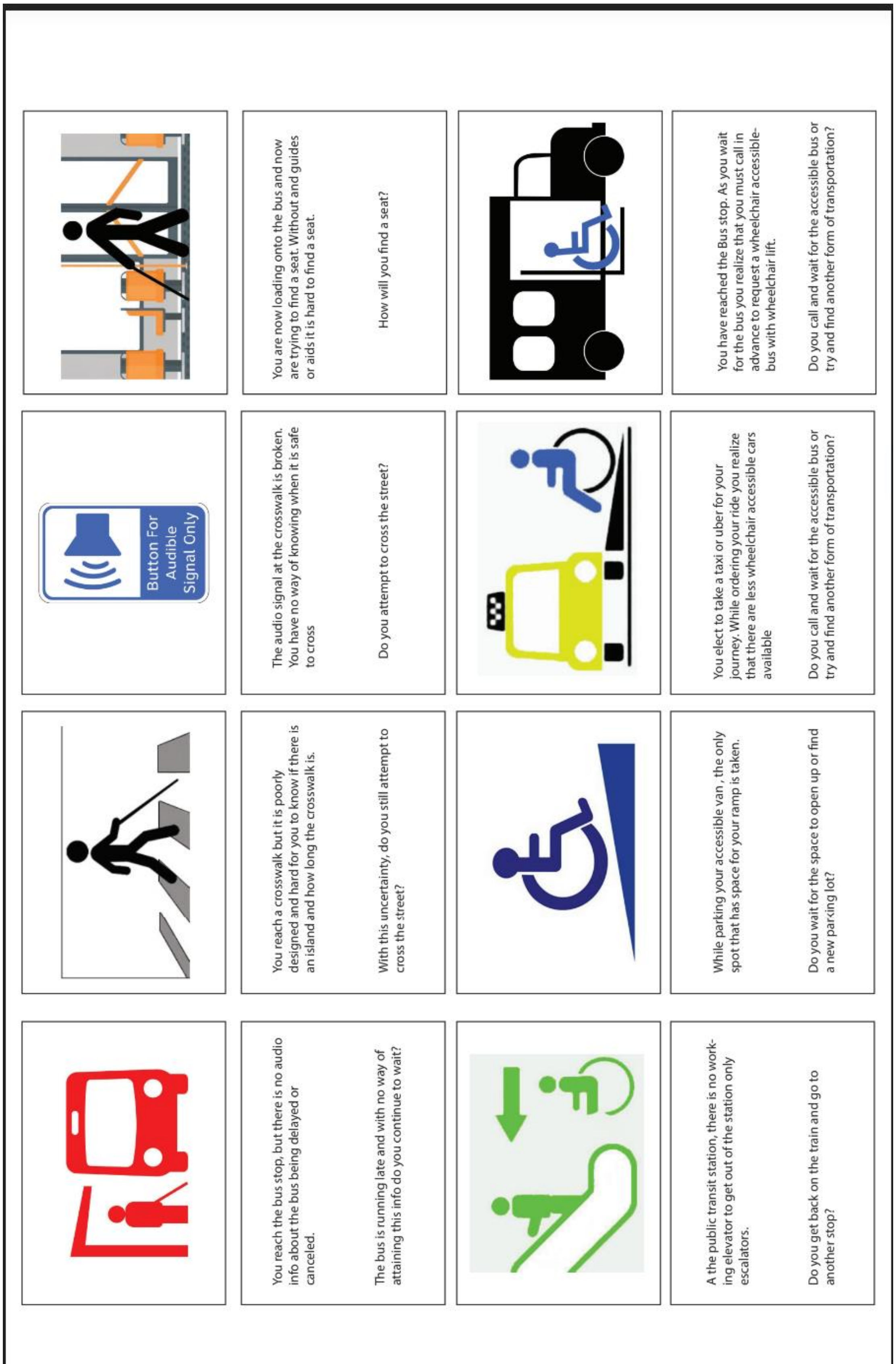
Some sketches of board game designs and graphical symbols from design studio:

A sketch of a modular game design

A sketch of a decision path game design incorporating symbols (icons)



A sketch of a graphic symbols (icons) depicting accessibility scenarios



A sketch of a graphic symbols (icons) depicting accessibility scenarios

Sketches of game design elements