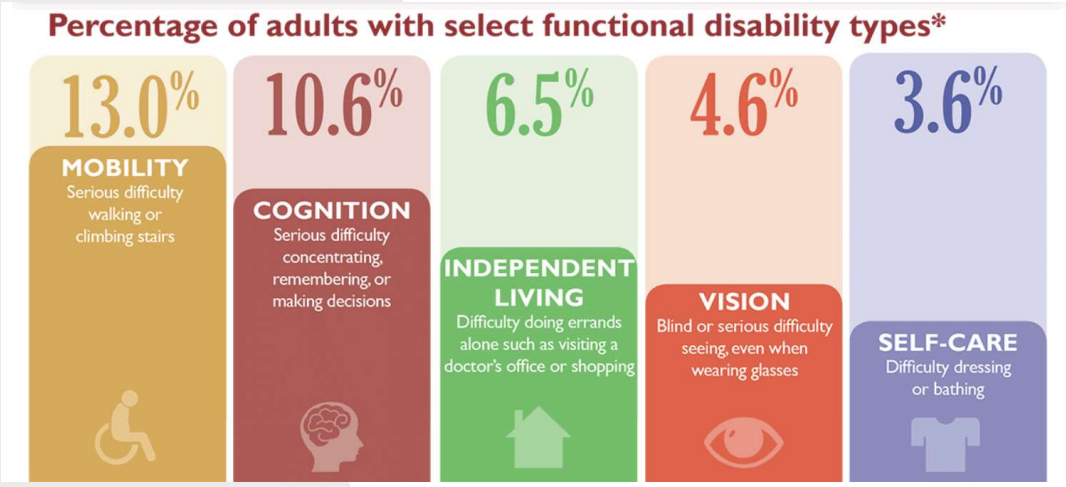
Pimp My Ride: Accessible Self-Driving Vehicles

Rory A. Cooper, PhD
Human Engineering Research Laboratories
University of Pittsburgh and US Department of Veterans Affairs

1

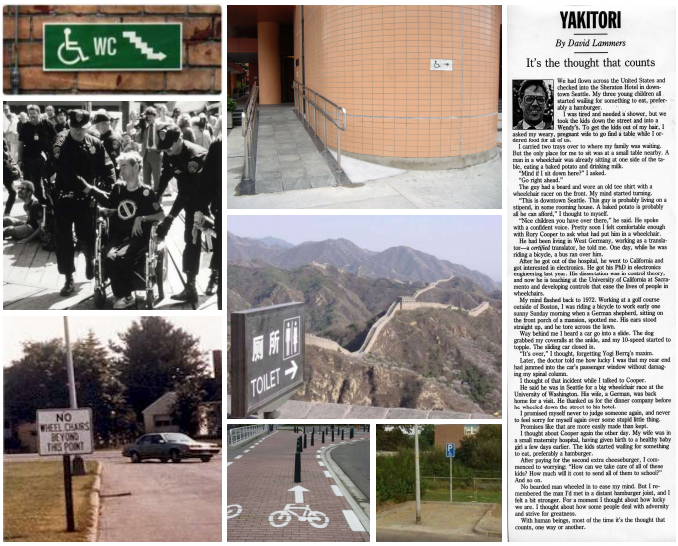
2



- https://www.cdc.gov/ncbddd/disabilityandhealth/infographic-disability-impacts-all.html

3

Attitudinal Barriers: the most difficult barrier to overcome

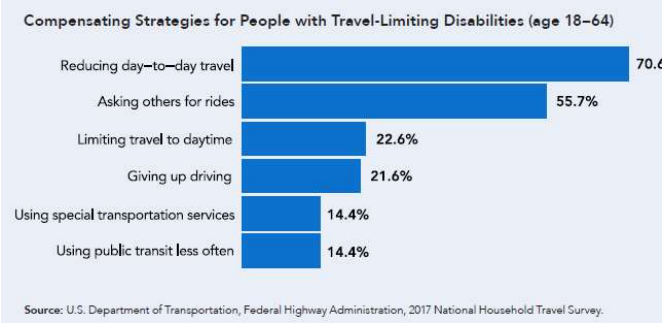


4

Landscape

- > 57 million Americans have a disability.
- Six million people with a disability have difficulty getting the transportation they need.
- No overarching federal laws specifically governing automated vehicles (AVs)
- National Highway Traffic Safety Administration (NHTSA) has released federal guidance
- Society of Automotive Engineers (SAE) international standard J3016 provides a common taxonomy and definitions for automated driving.
  - It defines more than a dozen key terms and provides full descriptions and examples for each level of autonomy.
  - Unfortunately, it neglects to address usability and accessibility for people with disabilities.

5



Travel Patterns of American Adults with Disabilities:

- Individuals with disabilities are a unique but sizable demographic. According to the U.S. Census, nearly one in five people in the United States have a disability. They also represent significant pent-up demand for transportation services. As a result, it is anticipated that there will be a notable increase in travel should fully automated vehicles succeed in expanding mobility access. ITS America "Driverless Cars and Accessibility" April 2019

6

Background

- Mitigating transportation related barriers for people with disabilities would enable new employment opportunities for approximately 2 million people with disabilities **and** save $19 billion annually in healthcare expenditures from missed medical appointments alone.
- Iezzoni et al. found that almost one-third of people with chronic conditions reported they did not have enough resources for transportation.
- Primary care physician are frequently unaware of their limited resources.
- Difficulties with transportation were often due to:
  - lack of accessible transportation
  - lack of awareness
  - limited information on available services
  - scheduling complication
  - high costs of transportation
  - limited availability of transportation for non-medical purposes
  - lack of funding in various insurance models
- Transportation issues faced by many subpopulations:
  - Older adults
  - People with intellectual and developmental disabilities
  - People with physical disabilities
  - People with sensory impairments
  - Minorities

7

More Background

- Douglass and Fox found that service utilization depends upon availability, affordability, and satisfaction with services
- Older adults who live alone or without spouses often have delayed medical care and barriers to care that include cost or lack of transportation
- In studies analyzing the impact of increased transportation access for people with disabilities, this change was consistently viewed as a positive one
- Both African-Americans and Hispanics were generally more likely to use transportation services and used them more frequently than Whites, and women within those two groups were more likely to use services than men

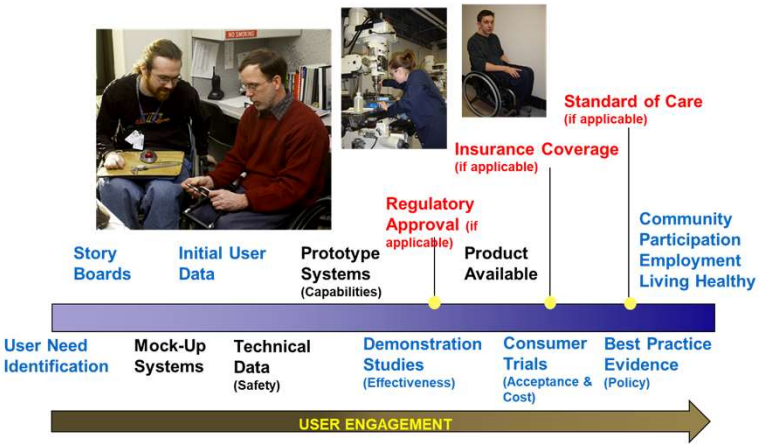
8

Nation Council on Disability

- "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."
- "Self-Driving Cars: Mapping Access to a Technology Revolution".
  - Report explored the "emerging revolution in automobile technology and the promise it holds to for people with disabilities, as well as the obstacles the disability community faces to realize that promise."
  - Recommendations:
    - (a) research and development of AVs or 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;
    - (b) guidelines are needed for how people with disabilities can safely interact with and use AVs in the environment where they need to use them;
    - (c) all types of common and public use AVs must be fully accessible.

9

Participatory Action Design and Engineering



- Participatory Action Design and Engineering Tools
  - Focus Groups
  - Story Boards
  - Expert Opinion
  - User Testing
  - User Acceptance

10

Voice of the Consumer

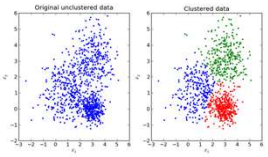
Table 1: Participant diagnoses (n = 1022; some selected > 1)

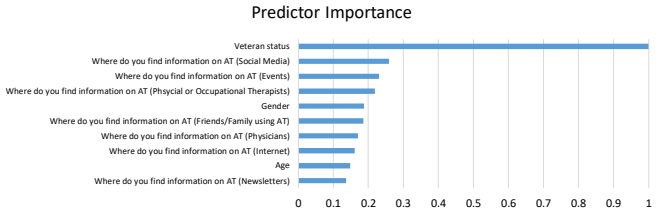
Diagnosis	N (%)
Spinal Cord Injury	491 (48.0)
Osteo/Rheumatoid Arthritis & Ortho Conditions	149 (14.6)
Multiple Sclerosis	115 (11.3)
Traumatic Brain Injury	81 (7.9)
Lower Limb Amputation	65 (6.4)
Cerebral Palsy	52 (5.1)
Muscular Dystrophy & Myopathies	44 (4.3)
Stroke	31 (3.0)
Spina Bifida	29 (2.8)
Amyotrophic Lateral Sclerosis	20 (2.0)
Upper Limb Amputation	5 (<1.0)
Cardio-pulmonary conditions	19 (1.9)
Post-polio syndrome	24 (2.3)
Osteogenesis Imperfecta, Fibrous Dysplasia, & Connective Tissue Disorders	16 (1.6)
Neuropathies	20 (2.0)
Cognitive Disabilities	10 (1.0)
Cerebellar, Balance, & Movement Disorders	17 (1.7)
Visual Disabilities	10 (1.0)
Other Diagnoses (not classified)	18 (1.8)

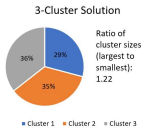
	Critical		Important		Minor Importance		Not Important	
	n	%	n	%	n	%	n	%
To live without a caregiver or with less assistance? (miss=0)	404	39.5	405	49.5	129	12.6	84	8.2
To go to work or school or be more productive at work/school? (miss=2)	360	35.2	365	35.7	111	10.9	184	18.0
To meet all of their personal mobility needs (e.g., home, work, neighborhood)? (miss=3)	589	57.6	368	36.0	43	4.2	19	1.9
To travel freely (e.g., vacation, cruise, airline, bus, taxi, train)? (miss=3)	527	51.6	405	39.6	63	6.2	24	2.3

11

Information Sources







Engaged; prefers obtaining info from the internet events, and conferences

- 100% military
- Oldest
- Largest proportion with SCI
- Lowest power chair users
- Using device 6+ years
- Mostly suburban
- Majority retired
- Educated
- High income
- Male

Disengaged; lowest internet users and prefers conferences the most

- 98% military
- Highest proportion MS
- Using device 2-5 years
- Mix of geographies
- Highest proportion high school ed only
- Lowest income
- Male

Prefers internet and family and friends for info

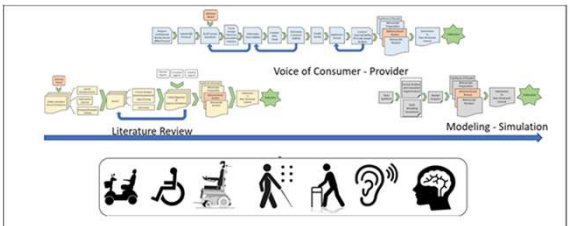
- Non- military
- Youngest
- Highest users of manual wheelchairs
- Highest proportion living in urban areas
- Majority using device 6-10 years-
- Highest proportion still working full-time
- College educated
- Women

12

DoT-UTC ASPIRE Activities

- Systematic literature review to describe the current state of the science
- Voice of the Consumer and Provider survey
- Journey mapping
- Focus groups

- **Elicit input from all key stakeholders on their experiences with, barriers to, and future needs and capabilities for accessible automated transportation**

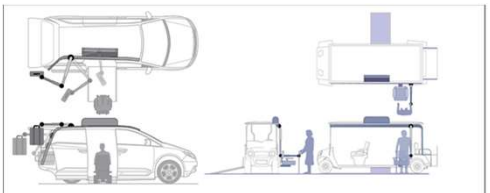


Flow Diagram of the ASPIRE Center major research and development activities.

13

DoT-UTC Aims

- **Aim 1**: Systematic Review
  - 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.
- **Aim 2**: Understand the needs of Users and Providers
  - Conduct surveys, focus groups, and journey mapping of stakeholders
  - Include 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).
  - Survey will be refined using pilot surveys, focus groups and journey mapping and then distributed broadly to all key stakeholders.



Example solid models to convey constraints and guidelines driven by data collected by the ASPIRE Center.

- **Aim 3**: Data synthesis, extrapolation, analysis and modeling
  - Synthesize data to understand current and future needs of potential stakeholders of accessible automated transportation and services.
  - Present summary survey findings, extrapolating findings to the greater population of potential automated vehicle users.
  - Combining data with publicly available datasets to understand factors that influence travel, displaying clusters of users based on their characteristics and needs
  - Ideation and development of solid models that illustrate key features and parameters for implementing automated vehicles and mobility services.
- **Aim 4**: Impact on Transportation System and Its Users
  - Provide a road-map for manufacturers and transportation system providers responsive to the needs of people with disabilities and demonstrates a path forward for the integration of accessible automated vehicles and mobility services.
  - Engaging and energizing stakeholders to create a community of practice that accelerates accessible automated vehicles and mobility services in an inclusive manner.
  - Be beneficial to the plurality of stakeholders and sensitive and responsive to the needs of edge users.

14

DoT-UTC Outputs and Expected Outcomes

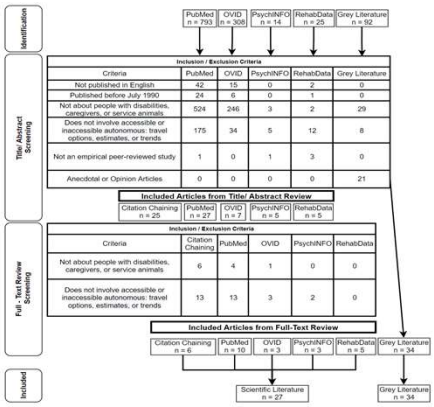
- **S**ummarize findings
- **E**xtrapolate findings to the greater population of potential automated vehicle users
- **C**ombines data with publicly available datasets to understand factors that influence travel, displays clusters of users based on their characteristics and needs
- **D**evelop solid model drawings that illustrate key features and parameters for implementing automated vehicles and mobility services.

- **Road-map for manufacturers and transportation system providers**
  - responsive to the needs of people with disabilities
  - demonstrates a path forward for the integration of accessible automated vehicles and mobility services.

15

Summary of Literature Review Findings

PRISMA Flow Diagram

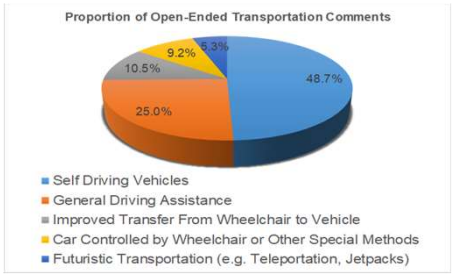


- The grey (n=34) and scientific literature (n=27) highlight opportunities and barriers to accessible automated vehicles (AVs) and services.
- Literature on <u>older adults</u> is most prevalent.
- Accessible AV design will need to include the <u>entire travel journey</u>.
- Solutions must be <u>tailored</u> to the needs and preferences of those with different disabilities and impairments.
- Clear need for <u>guidance on accessible design</u> and for <u>planning and policy surrounding AV technology and infrastructure</u>.
- <u>Research gaps</u> and <u>implications for policy and knowledge translation</u> outlined.

16

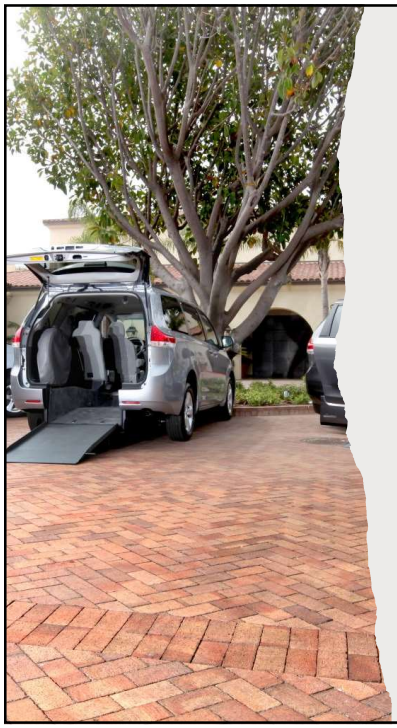
Accessible Autonomous Transportation – User Views

- Advancements in technologies related to transportation are very important to individuals with disabilities and represent a significant unmet need.
- Over 60% of respondents (n=612) rated the importance of technology in meeting their personal mobility needs (e.g. home, work, neighborhood) as "critical"
- Over 40% (n=438) felt that traveling freely (e.g. vacation, cruise, airline, bus, taxi, train) was also "critical."
- Of those participants who provided additional comments, approximately 12% mentioned transportation, with "self-driving" vehicles representing near 50% of the comments.



Voice of Consumer Transportation data

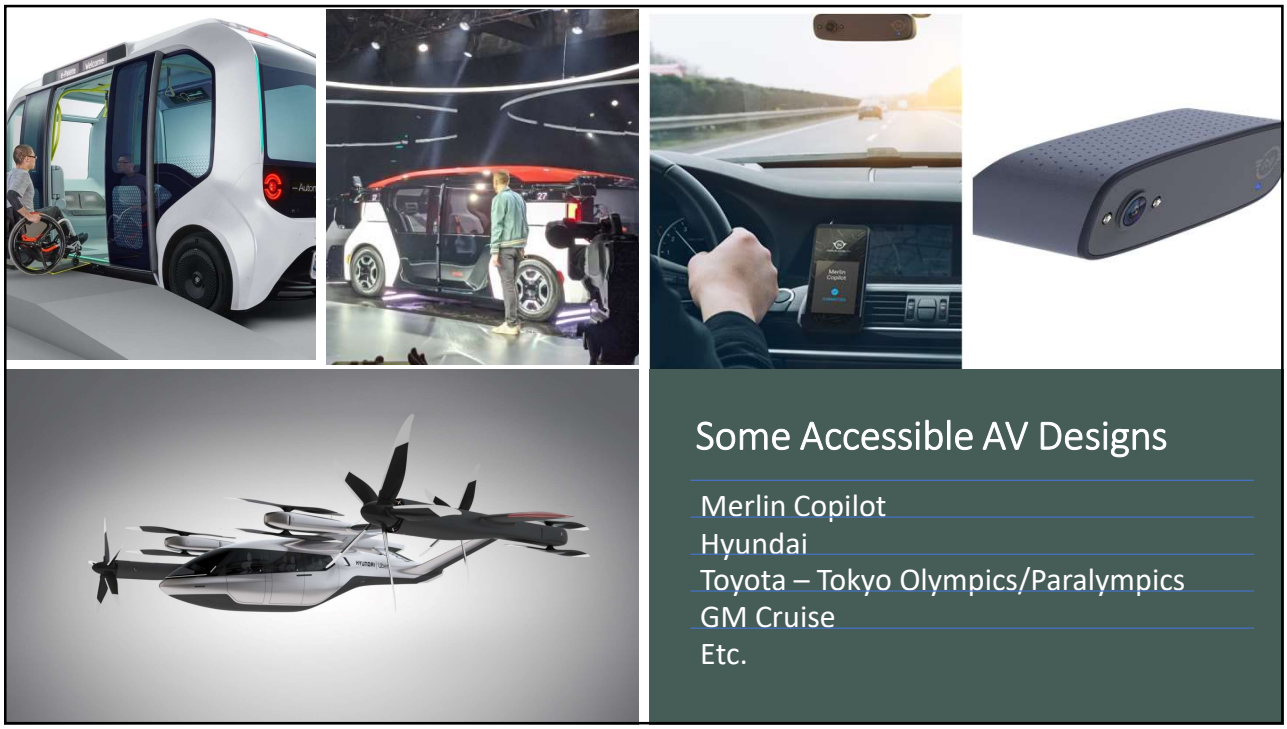
17



Early AV Commercial Steps

- **Lane Control -** Ability to stay safely within a lane - achieved by monitoring distances to lane markers, road edges and adjacent vehicles. Some systems utilize the global positioning system (GPS) for location.
- **Adaptive Cruise Control (ACC) -** an enhancement of common cruise control for maintaining a constant speed. ACC is dedicated to maintaining a safe distance from the vehicle imeditely ahead.
- **Automatic Emergency Braking System (AEBS) -** automatically stops the vehicle to avoid a collision.
- **Street Sign Recognition -** processes sensor data to identify road signs. Although products do exist, this technology remains the subject of research and development.
- **Vehicle-to-Vehicle (V2V) Communication -** vehicles work together to improve the safety of the roadway system, including the vehicles on it.
- **Object or Collision Avoidance System (CAS) -** integrates multiple features, such as object detection or identification and AEBS to avoid a collision.
- **Smart Navigation** – provides directions based upon user capabilities and preferences.

18



Some Accessible AV Designs

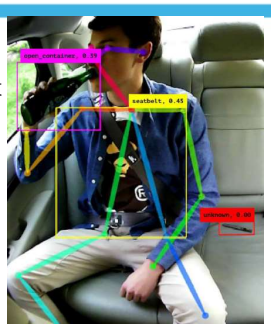
- Merlin Copilot
- Hyundai
- Toyota – Tokyo Olympics/Paralympics
- GM Cruise
- Etc.

19

Next Generation Mobility Example

https://youtu.be/jVqrlA40R0I

- Passenger Management System



- Field support

- Automated Electric Vehicle
https://youtu.be/jVqrlA40R0I

- Advance Back end monitoring and control Center

- Interactive Speech

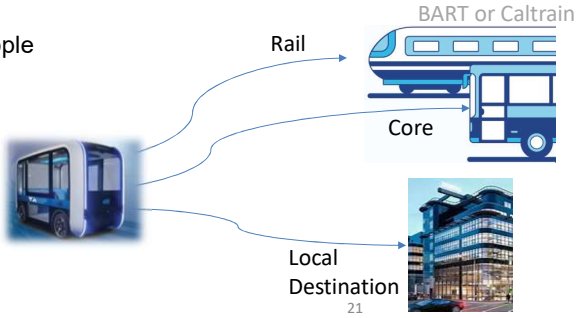
Solutions that move you

Santa Clara Valley, CA

20

Example End Game - First and Last Mile Solutions

- Deliver a cost effective first and last mile solution
- Reshaping VTA non-core transit, from a rigid system of fixed routes and schedules to a fully dynamic network feeding the core and rail service.
- Leveraging technology that complements the best of public transportation with the convenience of a private car. Take people where they need to go in the quickest, most affordable, and environmentally responsible way possible.



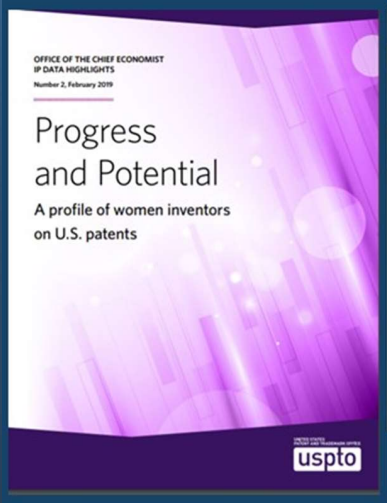
Santa Clara Valley, CA

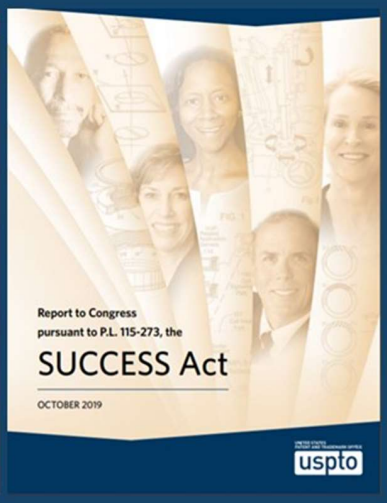
Solutions that move you

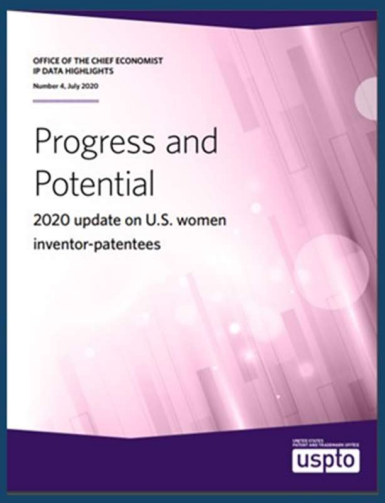
21

21

Opportunities for innovation







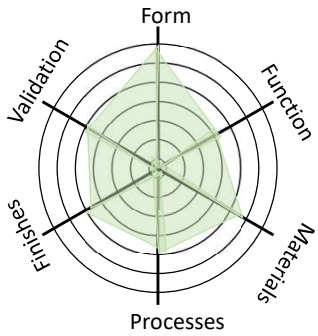
22

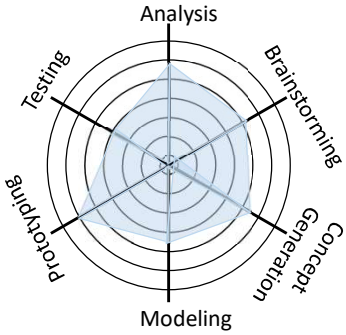
Design Tools

- Design Trade-offs
  - Strength/Weight
  - Stiffness/Form
  - Cost/Quality
- Engineering Factors
  - Materials
  - Processes
  - Finishes
  - Form
  - Function
  - Validation

3D Modeling (Solid Modeling)

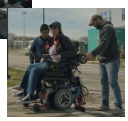
- Accelerate design process
  - Explore possibilities
- Create "Story Boards"
- Translate concepts to designs
- Convert designs to plans
- Integrate with 3D printing





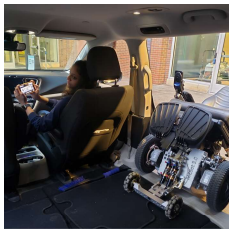
23

MEBot



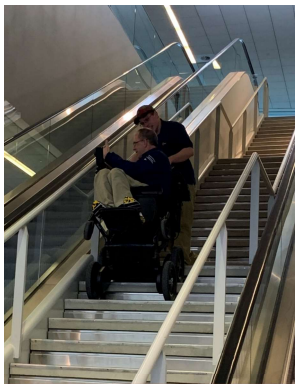

- Compare MEBot to own chair.
- Powered Mobility Clinical Driving Assessment (PMCDA); Satisfaction Questionnaire; National Aeronautics and Space Administration's Task Load Index (NASA-TLX).



- Significantly higher number of tasks (*p=.004*)
- Significantly higher scores in both the Adequacy-Efficacy (*p=.005*) and the Safety (*p=.005*) domains PMCDA while using MEBot over curbs and cross-slopes.
- Significantly higher mental demand (*p=.005*) while using MEBot to navigate curbs and cross-slopes.

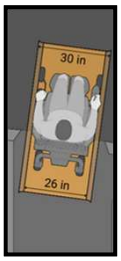
24

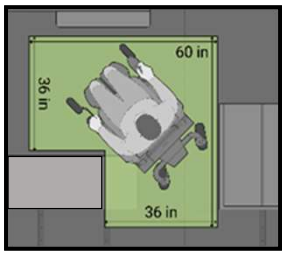
iBot

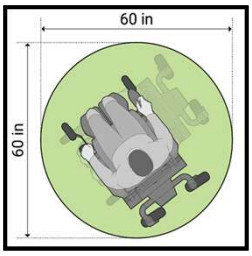



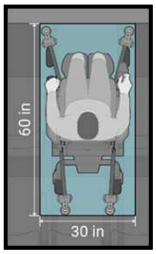
25

Space Requirements



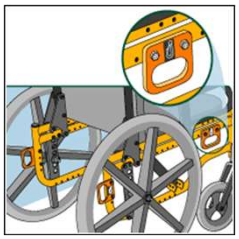


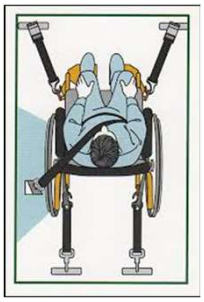


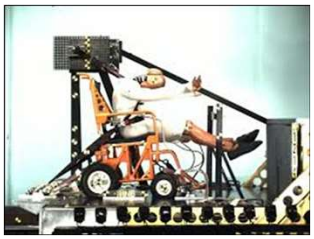


26

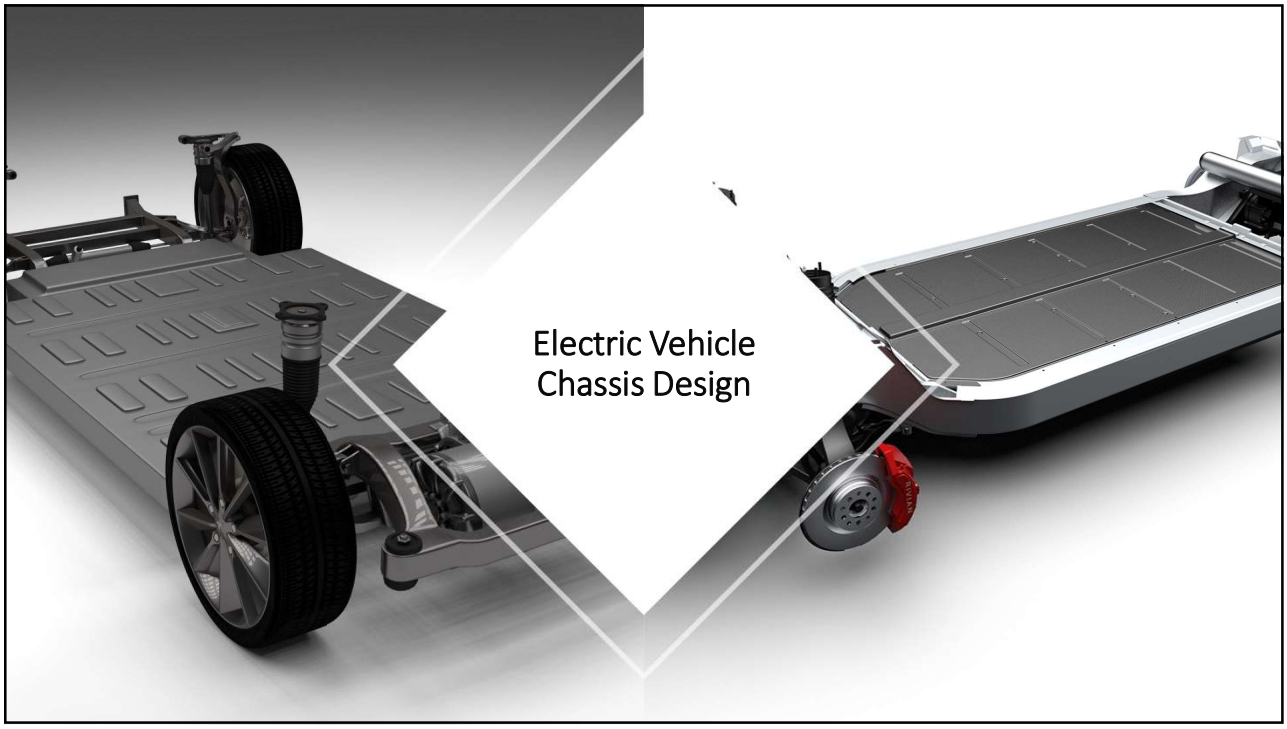
Wheelchair Securement and Safety







27



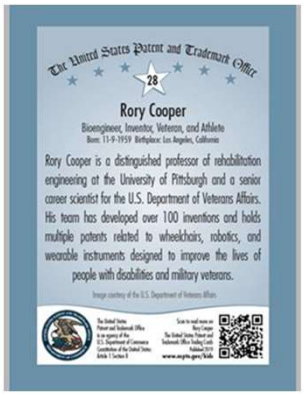
28

Turn Adversity to Advantage and Action to Accomplishment

- Rory A. Cooper, PhD
- Human Engineering Research Labs
- Suite 400
- 6425 Penn Avenue
- Pittsburgh, PA 15206

- (99+) Rory Cooper | LinkedIn
- Rory A. Cooper - Google Scholar
- Rory A. Cooper - Wikipedia

- For resources see: www.herl.pitt.edu



29