The event will begin momentarily.

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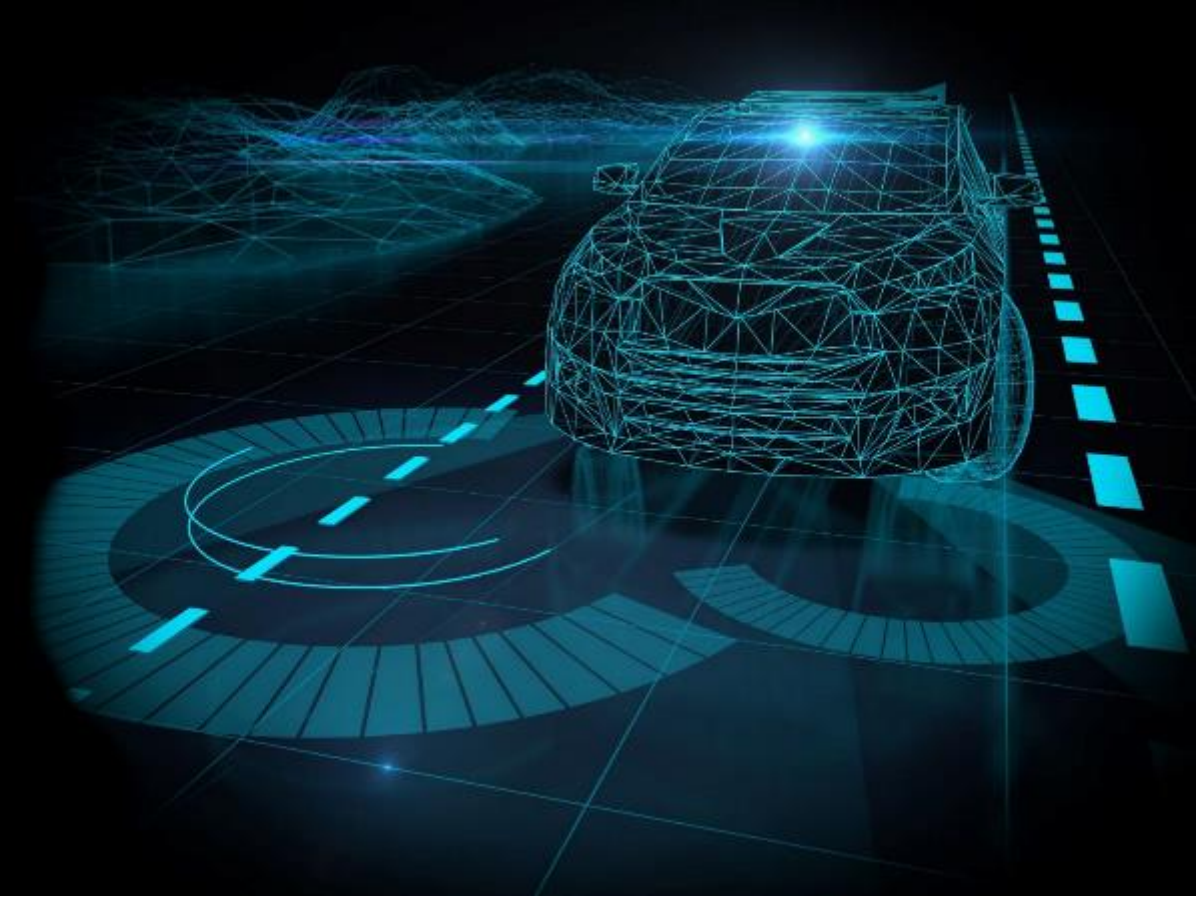
Inclusive Design of Autonomous Vehicles: A Public Dialogue



Accessibility for Passengers with Mobility Disabilities: Part 1
Entering and Exiting Vehicles

Agenda

- Presentations
  - U. S. Access Board – Randall Duchesneau
  - University at Buffalo – Dr. Victor Paquet
  - Q & A
  - NMEDA – Amy Schoppman
  - BraunAbility – Kevin Frayne
  - Q & A
- Open Dialogue
- Dialogue continues online
  - https://transportationinnovation.ideascale.com/

PowerPoint slides available for download at:
https://www.access-board.gov/av/

How to Participate

- Ask Questions to Presenters
  - Submit questions using Zoom's Q & A feature throughout the event
  - Moderator will read question
  - May not get to all questions
  - Alternative : Email events@access-board.gov
- Contribute to Open Discussion
  - Request to speak using Zoom's Q & A feature
    - Ex. I'm Beth from XYZ Company and would like to talk about automated doors
    - Ex. I'm Alex and I'd like to share my experience using an AV
  - Host will enable your microphone
  - Moderator will call on you to unmute and speak
  - ASL – if you wish to be visible for signing, indicate in request
- Online dialogue
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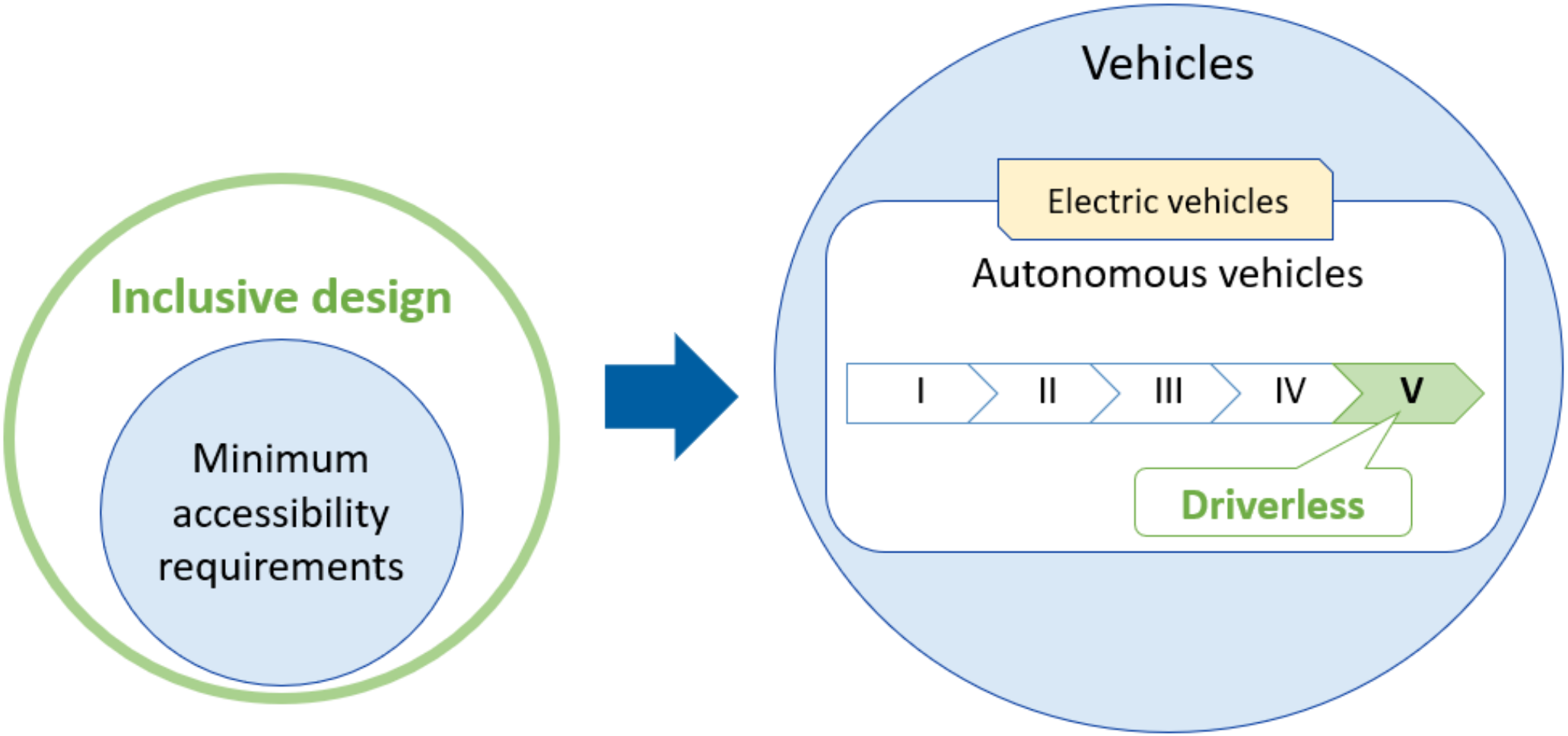
  - For assistance, email: ePolicyWorks@dol.gov

“inclusive design of autonomous vehicles”



Existing Accessibility Guidelines

- ADA Accessibility Guidelines for Transportation Vehicles (1991, 1998)
  - https://www.access-board.gov/ada/vehicles/

- Updated Guidelines for Buses and Vans (2016)
  - https://www.access-board.gov/guidelines-standards/vehicles/update-buses-vans/guidelines-text/

For technical assistance on these guidelines:

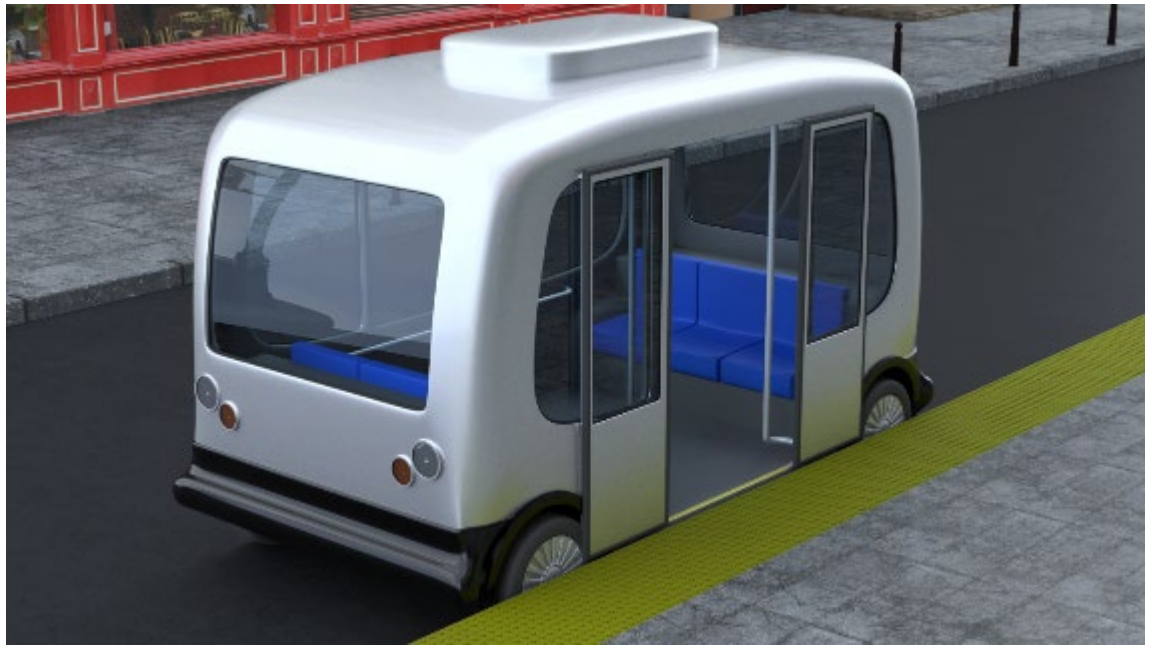
- 800-872-2253 (v)
- 800-993-2822 (tty)
- ta@access-board.gov

U. S. Access Board: Accessibility Guidelines for Buses and Vans

Randall Duchesneau, Accessibility Specialist

Technical Criteria

- Walking Surfaces
- Ramps and bridge plates
- Slopes
- Lifts
- Level boarding
- Steps
- Doorways
- Illumination

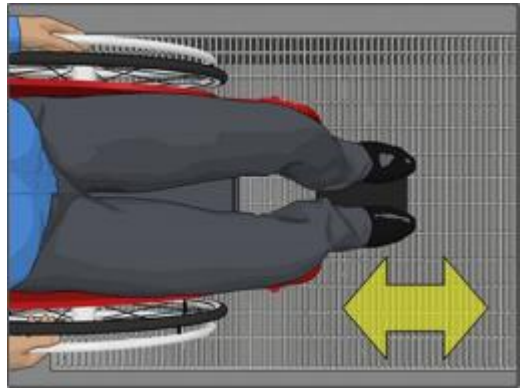


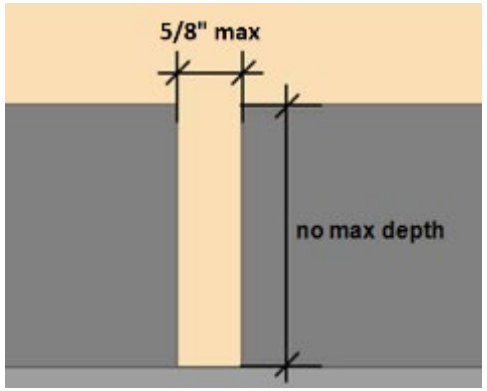
Entering and Exiting Vehicles

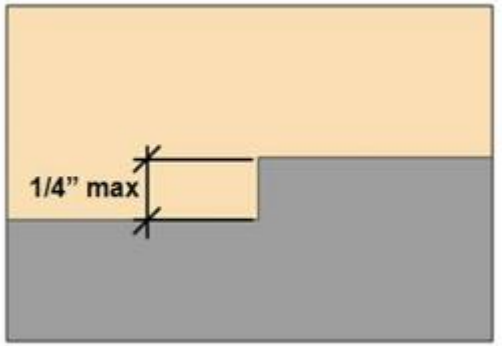
- At least one means of accessible boarding and alighting (ramps or bridge plates, lifts, level boarding)
- At least one means that can be deployed to the roadway

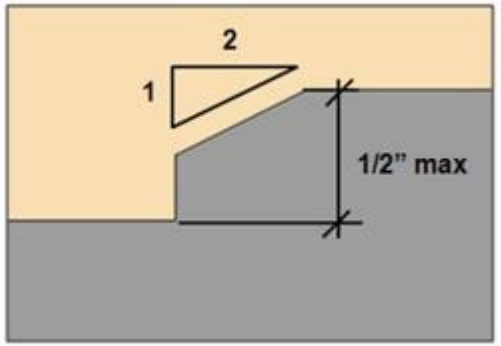
Surfaces

- Slip resistant
- Openings
  - 5/8” sphere
  - Perpendicular to dominant direction of travel
  - Exception for wheelchair securement components and handles
- Surface discontinuities
  - ¼” vertical, ½” beveled at 1:2
  - Steps









Level Boarding

- Coordinated to minimize the gap between the vehicle floor and boarding platform
- Ramp needed if gap is greater than 2” horizontal or 5/8” vertical

Ramps

- Permitted to fold or telescope
- Design load
  - 600 pounds if longer than 30”
  - 300 pounds if less than 30”
  - (Placed at the centroid of the ramp distributed over an area of 26” x 26”)
- When in use, firmly attached to the vehicle
- When not in use, means of storage (i.e. compartment / securement system)
- Capable of manual operation (in case of power failure)

Ramp features

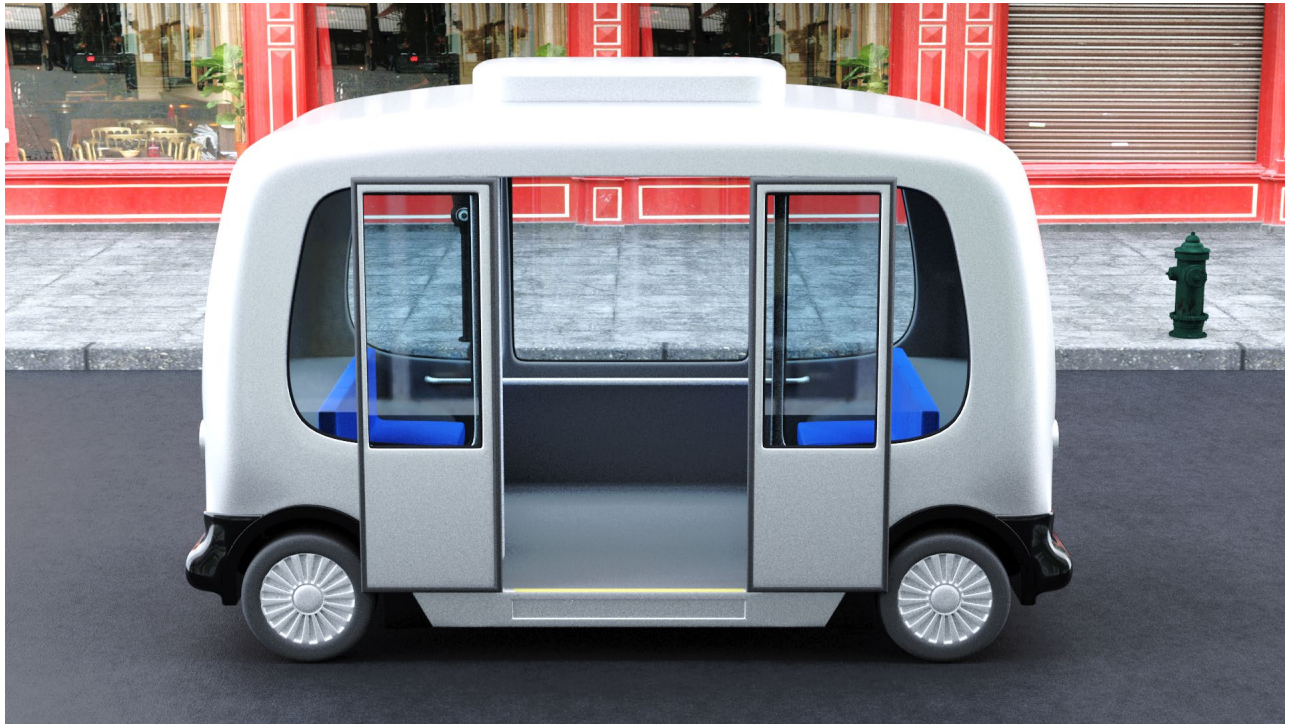
- Clear width 30” wide (min.)
- Edge guards
  - 2” high (min.) along each side to within first 3”
- Visual contrast
  - 1” (min.) stripe along perimeter
  - Light on dark, or dark on light
- Slopes

Lifts

- Comply with NHTSA FMVSS:
  - 49 CFR 571.403 and 571.404
- Designed to permit boarding facing toward or away from vehicle

Doorways

- Vertical clearance (min.)
  - Finished edge of door opening to highest points of the deployed lift, ramp or bridge plate below
  - Depends on size and type of vehicle
    - Over-the-road buses – 65”
    - Other vehicles < 25 feet – 56”
    - Other vehicles > 25 feet – 68”
    - [Buildings: 78” - 80”]
- Clear width
  - 32“ min. for doorways with level boarding
- Thresholds marked with 1“ stripe



Illumination

- Lights shielded (don’t project directly into eyes of passengers)
- Required at ramps, bridgeplates, doorways
  - 2 foot-candles (22 lux) min.
- Required at boarding and alighting areas (exterior illumination)
  - 3 feet (min.) beyond ramp/steps
  - 1 foot-candle (11 lux) min.

Victor Paquet, ScD

Center for Inclusive Design and Environmental Access

University at Buffalo
Department of Industrial and Systems Engineering

ACCESSIBILITY FOR PASSENGERS WITH MOBILITY DISABILITIES: PART 1

BOARDING AND EXITING

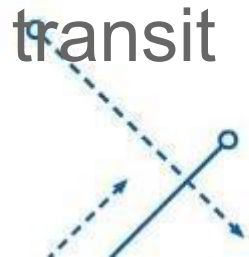
Victor Paquet, ScD

U.S. Access Board Public Forum on Autonomous Vehicles

University at Buffalo
Center for Inclusive Design and Environmental Access
School of Architecture and Planning

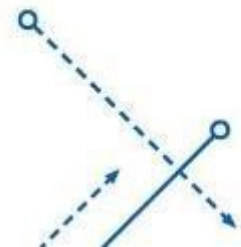
Introduction

- While ramps afford accessibility that stairs do not, all ramps are not created equal.
  - Boarding and exiting public transit vehicles via ramps can be challenging.
- Today's presentation will summarize the results of two vehicle ramp studies:
  - **Study 1:** Effects of ramp slope on human performance during ramp ascent and descent
  - **Study 2:** Effects of multi-segment ramp configuration on human performance during boarding and exiting in a simulated vehicle environment
- Some of the findings can be applied to public autonomous public transit (i.e., public self-driving vehicles).



Study 1: Research Questions

- What is the impact of ramp slope on the ramp ascent and descent performance of mobility aid users?
- Does ramp slope have a differential effect on the performance of individuals who use different types of mobility aids?



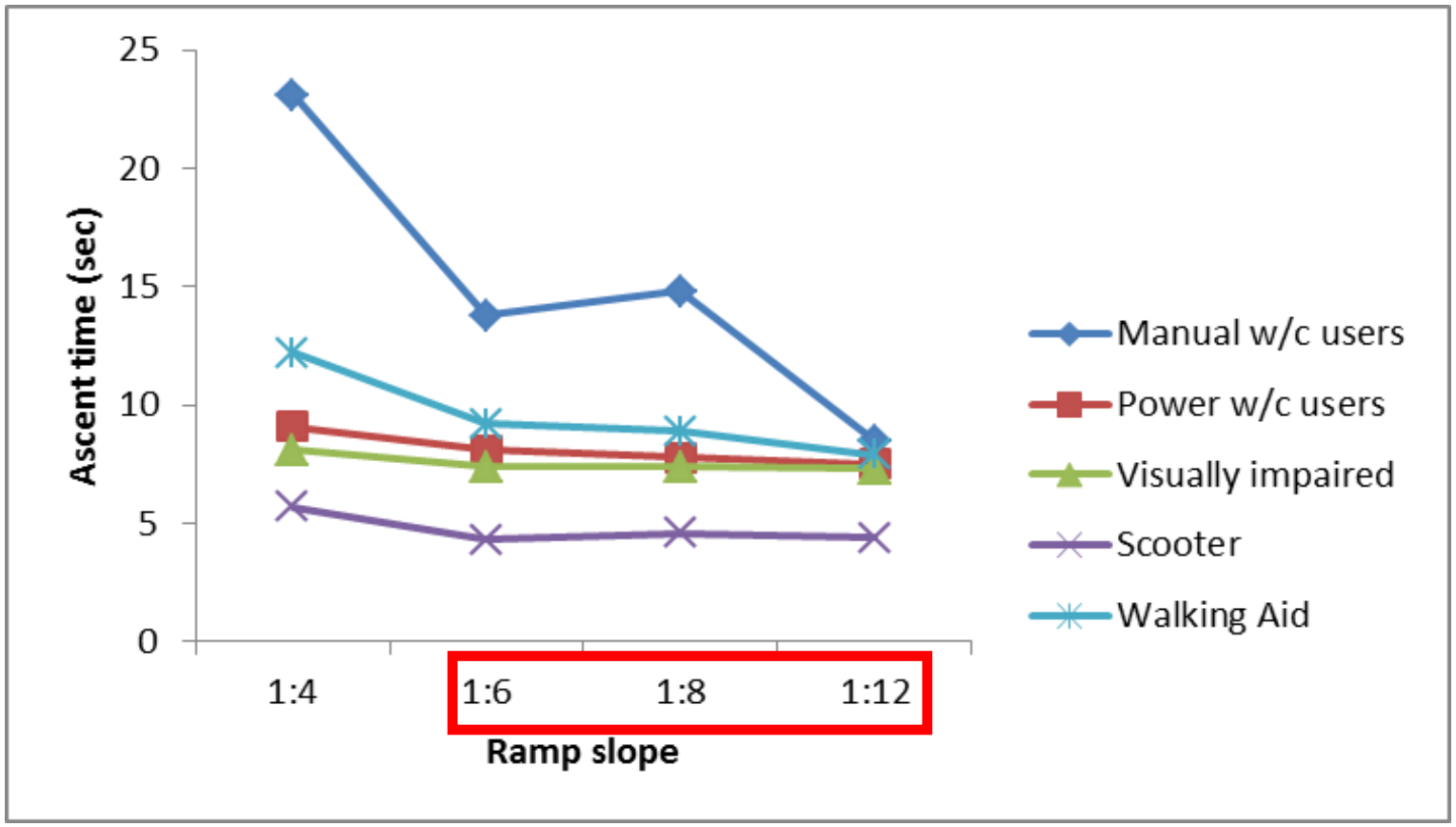
Study 1: Study Design (n=80)

Group	n	Age Range
Manual Wheelchair	14	19-55
Power Wheelchair	20	29-82
Scooters	5	29-65
Cane/Service Animal (Visually Impaired)	20	22-75
Other Walking Aid	21	28-80

1:12 **1:8** **1:6** **1:4**




Study 1: Ramp Ascent Time



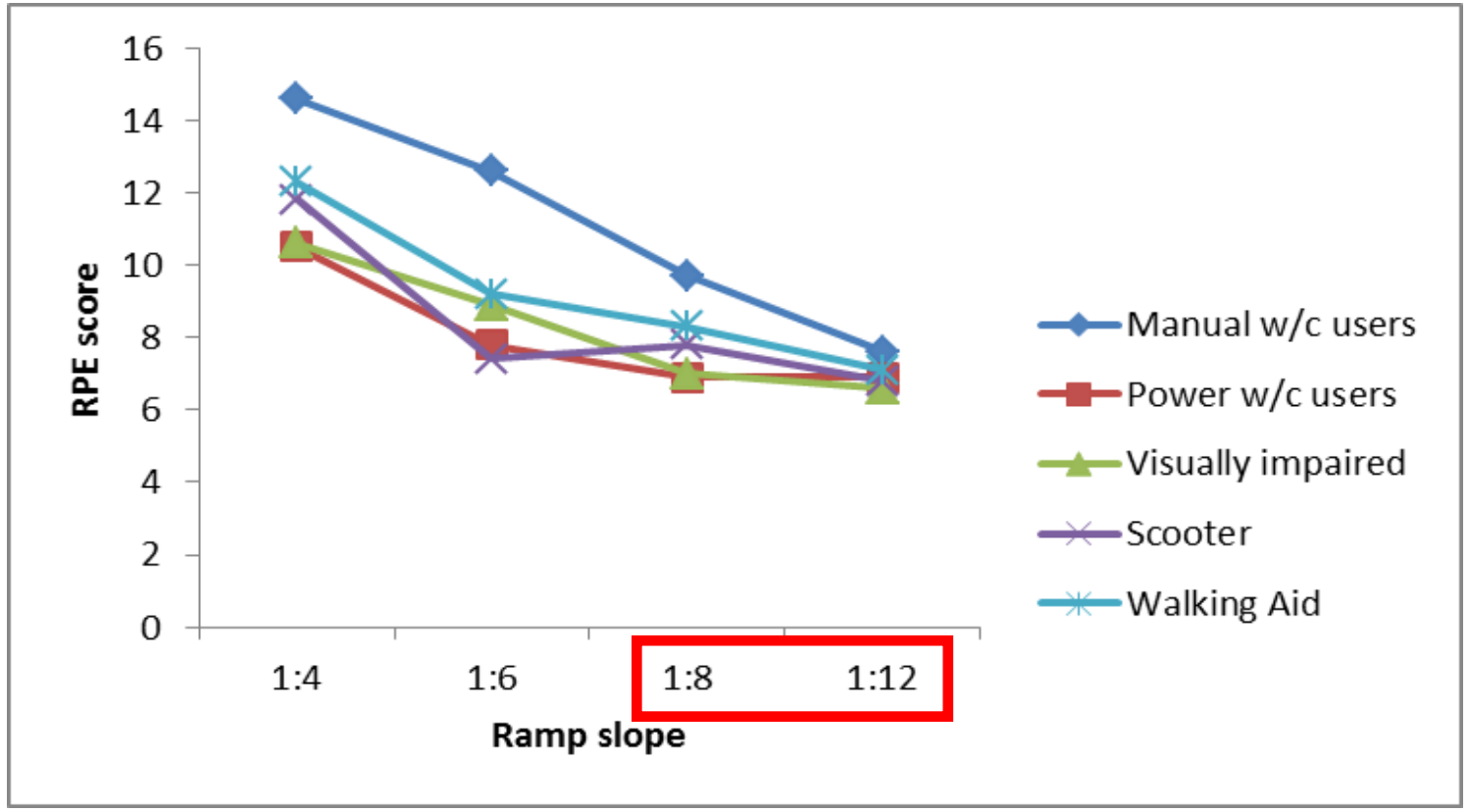
ANOVA: Main effects for user group (p<.001) & slope (p=.027).

Study 1: Ratings of Perceived Exertion for Ramp Ascent

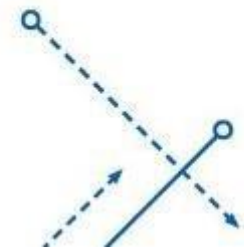
Hard

Somewhat Hard

Very light



ANOVA: Main effects for user group ($p<.001$) and slope ($p<.001$).

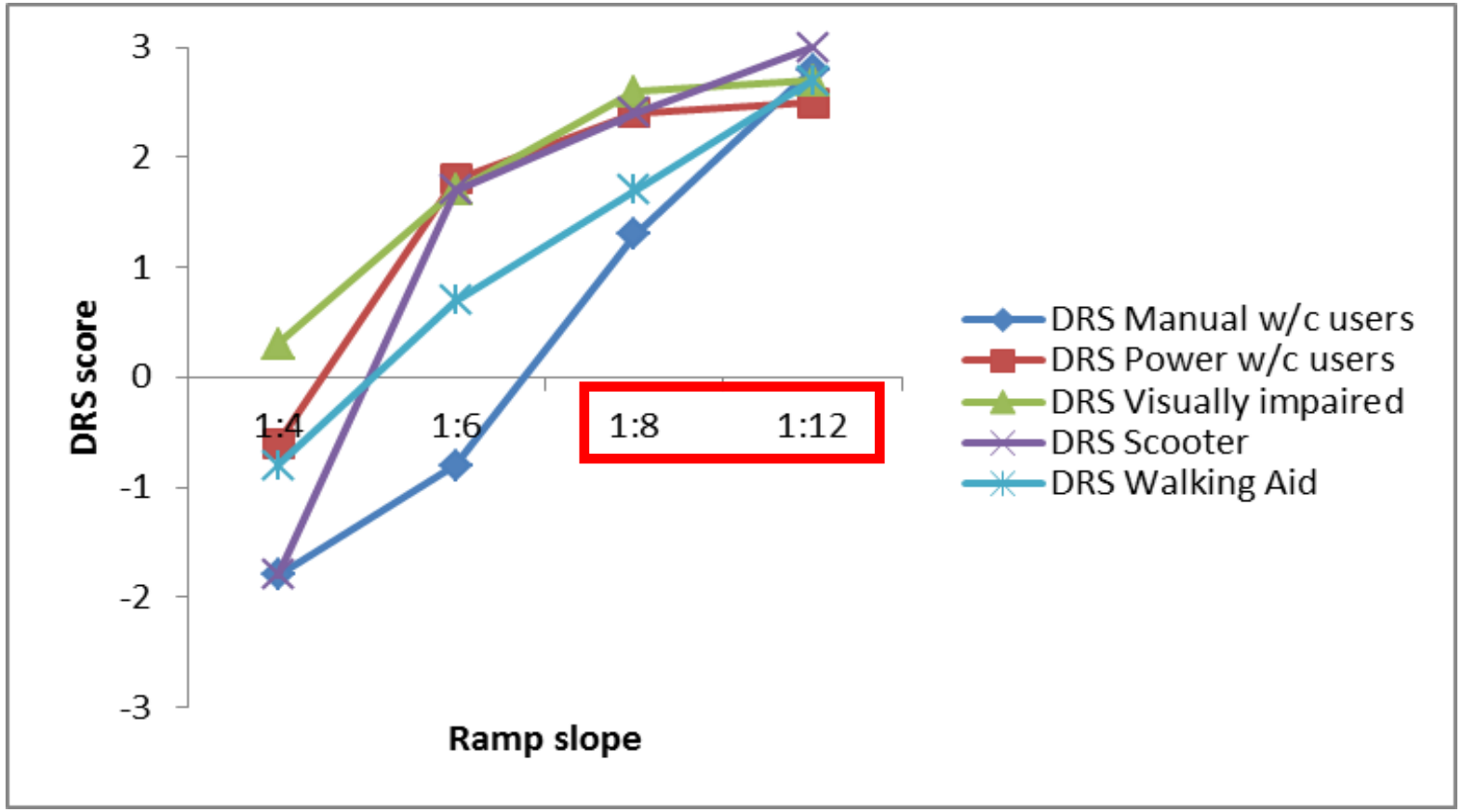


Study 1: Ratings of Perceived Difficulty for Ramp Ascent

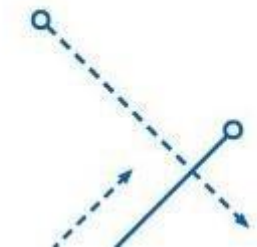
Very Easy

Very Neither

Very Difficult



ANOVA: Main effects for user group ($p<.001$) and slope ($p<.001$).



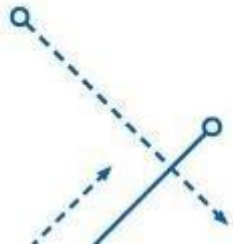
Study 1: Other Findings

Successful Use

- 1:4 – 9 (33%) could not complete trial
- 1:6 – 4 (14.8%) could not complete trial
- 1:8 – 1 (3.7%) could not complete trial
- 1:12 – all completed trial

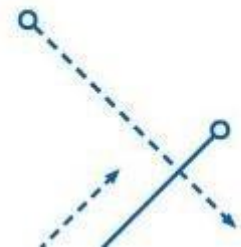
Usability

- Power WC users, individuals with VI, and ambulation aids users rated **descent** more difficult than ascent at slopes of 1:4 and 1:6.
- Some participants expressed concerns about using the ramp in *winter.*



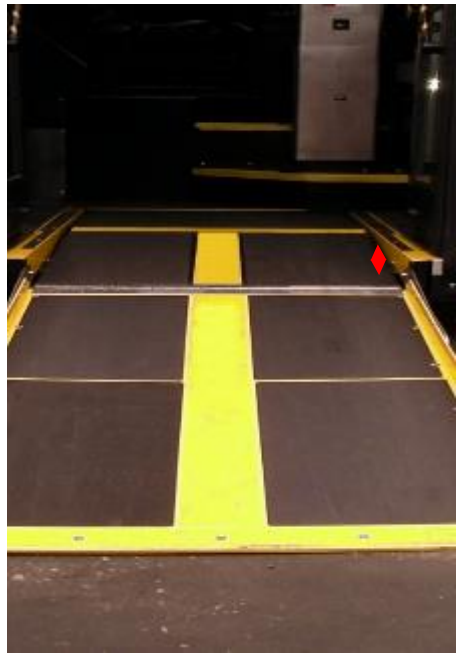
Study 2: Research Questions

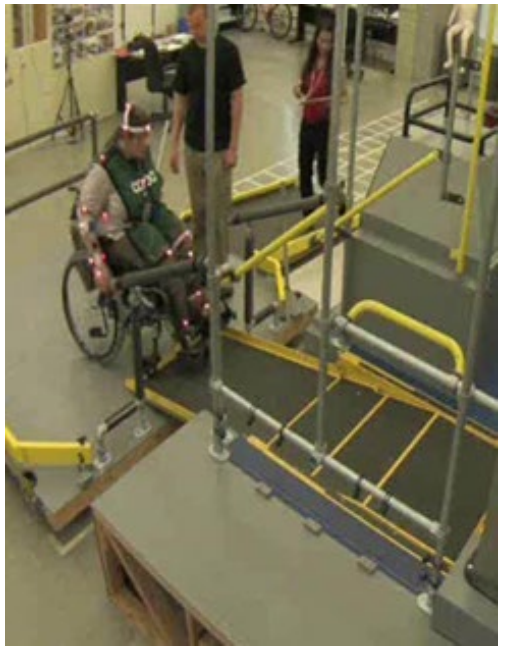
- Does the ramp deployment landing height for a multi-segment bus ramp affect user performance as users enter or exit the bus?
- Do the slopes of a multi-segment bus ramp differentially affect users of different types of mobility aids?



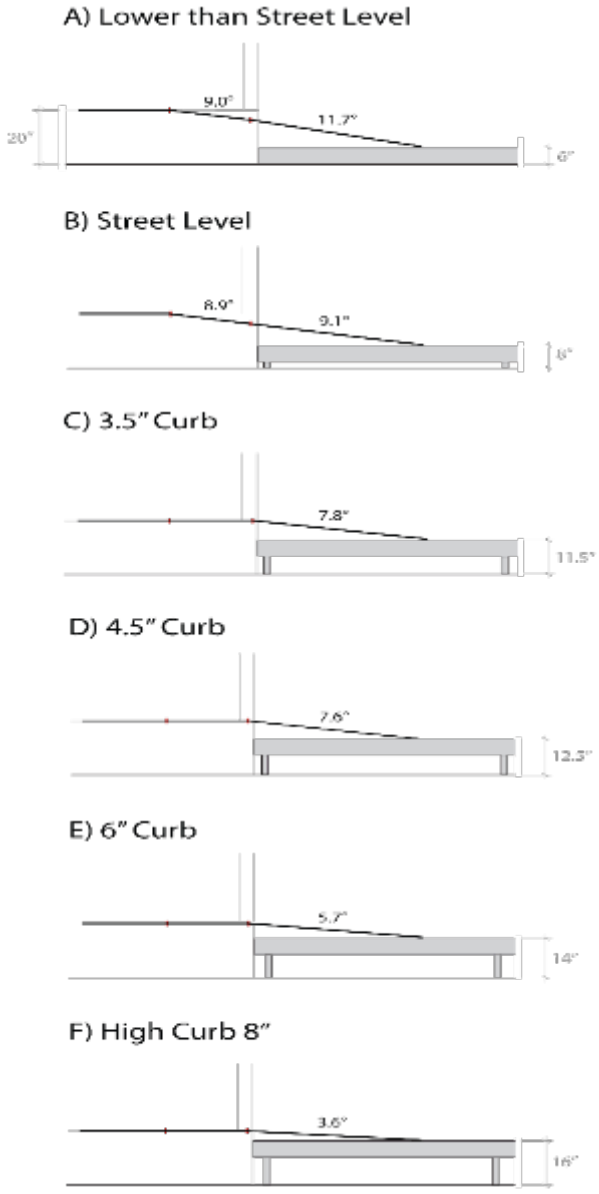
Study 2: Study Design (n=66)

Participant Group	n
Manual Wheelchair	15
Power Wheelchair	15
Scooter	6
Cane/Service Animal (Vision Impaired)	15
Walking Aid	15

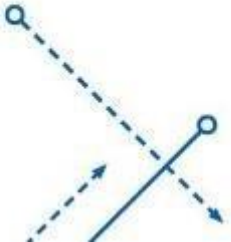




Study 2: Test Conditions

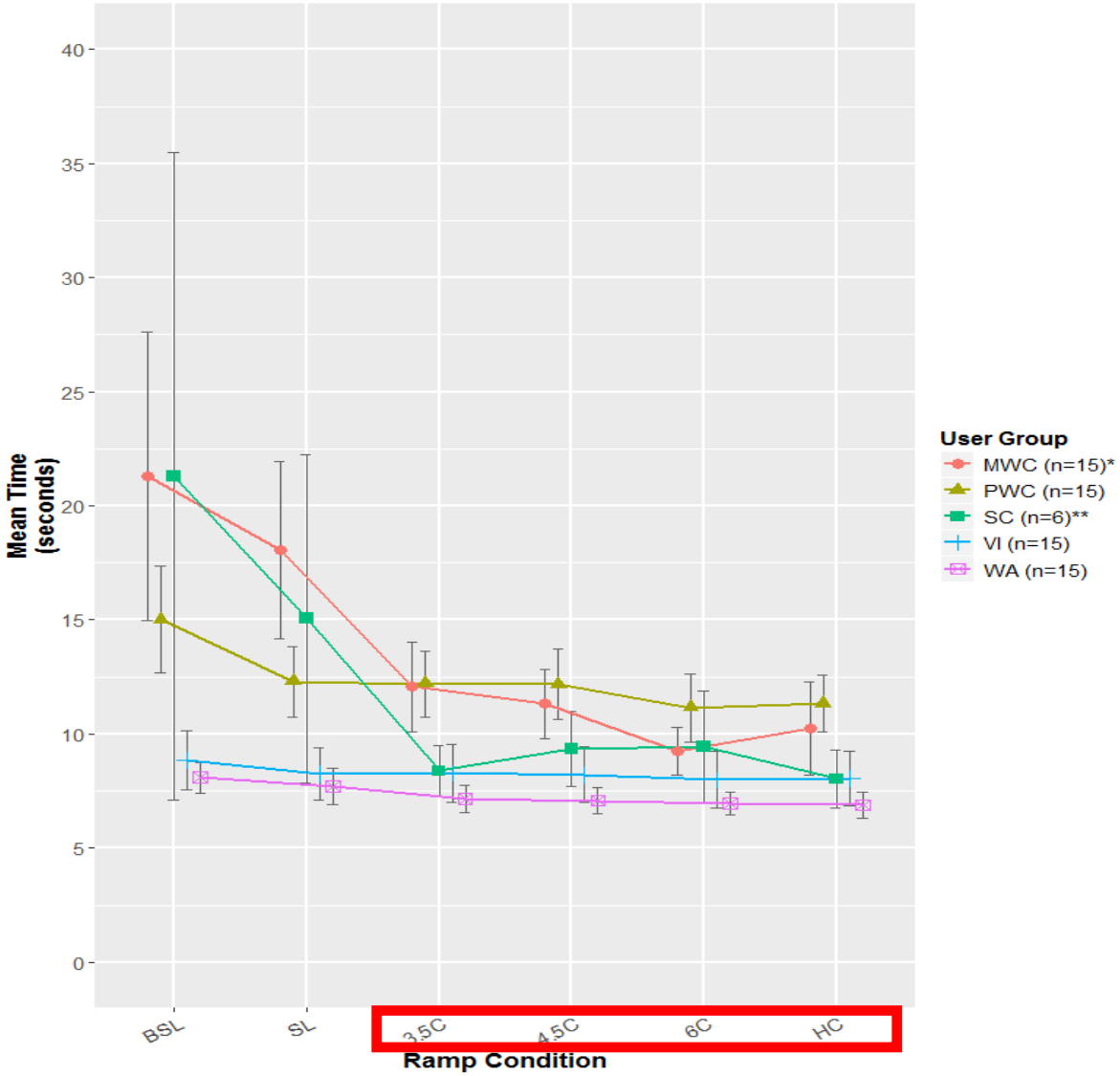


Ramp Condition	Segment Angle (rise:run equivalent)		
	Inside	*Middle*	*Outside*
A. Below Street Level	1.2° -	9.0° (1:6.3)	11.7° (1:4.8)
B. Street Level	1.3° -	8.9° (1:6.4)	9.1° (1:6.2)
C. 3.5" Curb	1.3° -	2.5° -	7.8° (1:7.3)
D. 4.5" Curb	1.3° -	0.4° -	7.6° (1:7.5)
E. 6" Curb	1.3° -	0.3° -	5.7° (1:9.9)
F. High Curb 8"	1.3° -	0.3° -	3.6° (1:15.7)

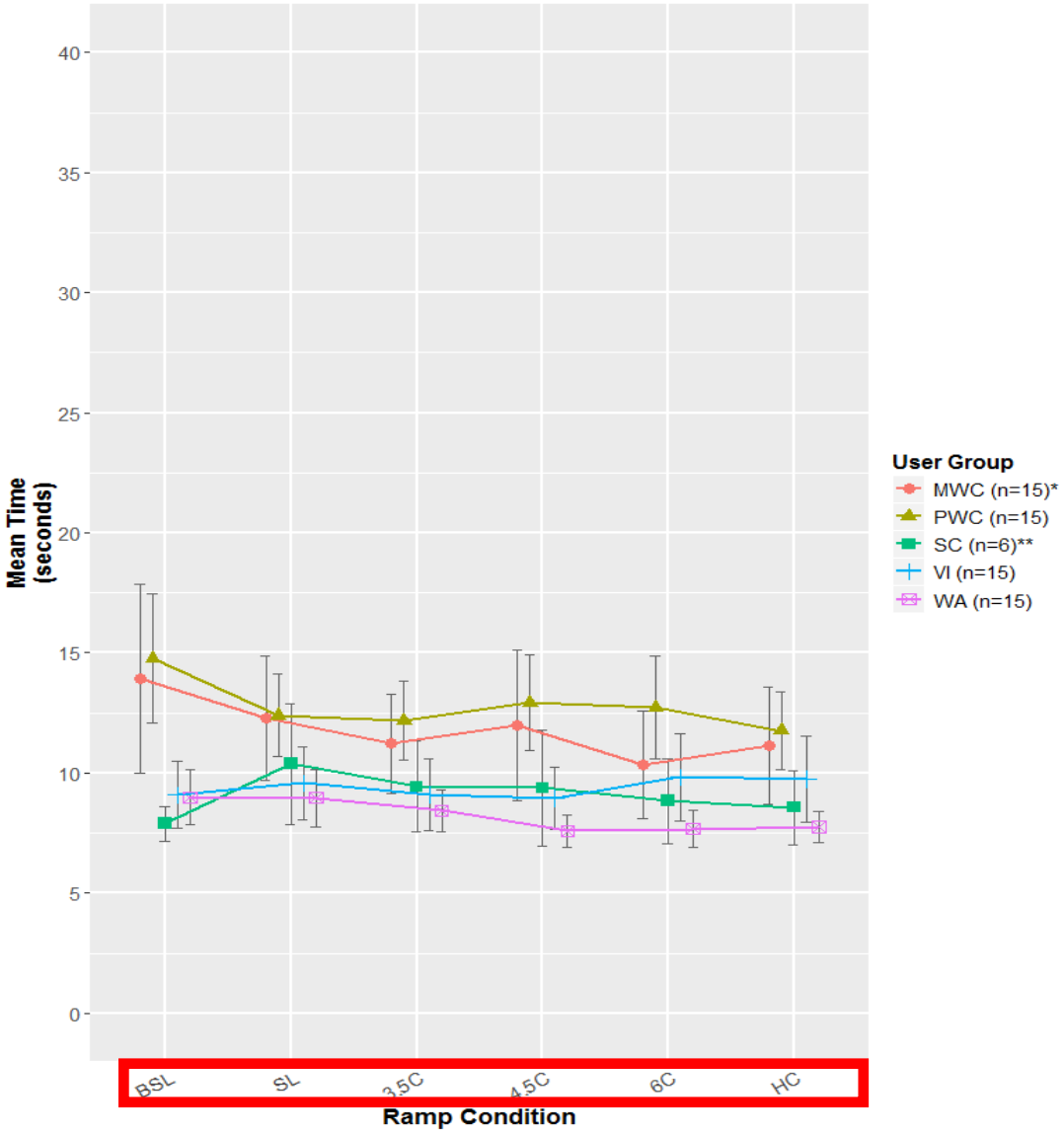


Study 2: Findings (Time)

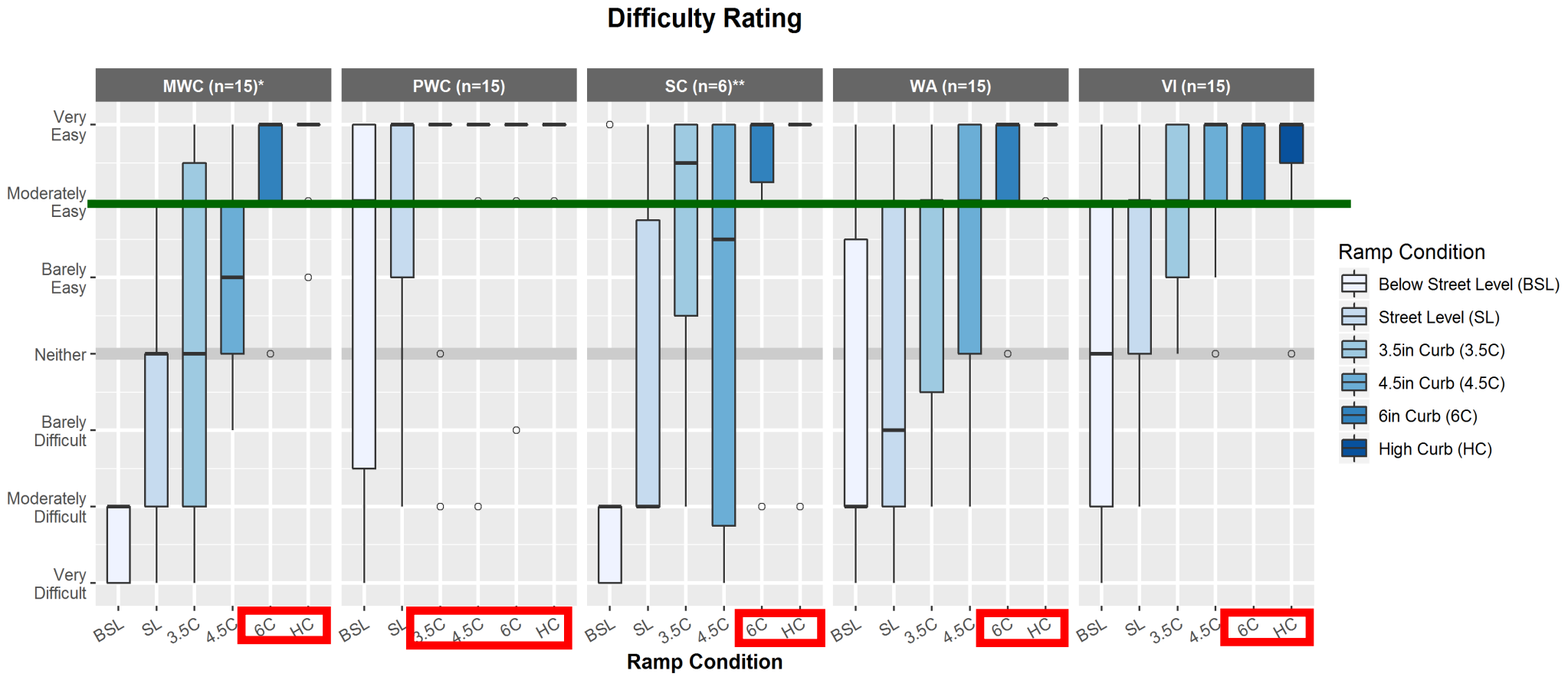
Ascent



Descent

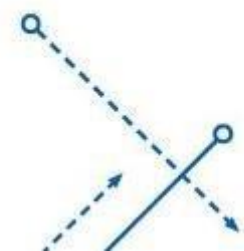


Study 2: Findings (Difficulty Ramp Ascent)



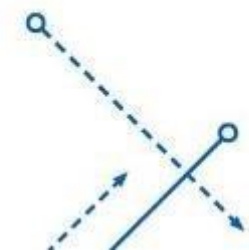
Study 2: Other Findings

- 20% of manual wheelchair users need assistance even on a 4.5 inch curb (steepest segment measures 1:7.5).
- The challenging grade break conditions created with older (two-segment) ramps were alleviated by the three-segment ramp design.
- Ramps should be designed to be at floor grade within the bus (i.e., do not cut into floor) to reduce trip and fall hazards and maximize clear spaces for turning and maneuvering.



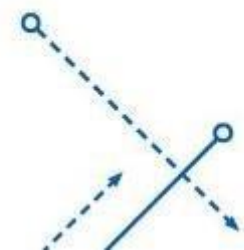
Research Implications for Self-Driving Vehicles

- Our work supports a maximum slope for transit ramps of 1:6, with less severe slopes preferred to support independent ascent of manual wheelchair users.
- With a 1:6 maximum condition at street level, any environmental facilitation will support easier entry and exit:
  - Deploy ramp to curb wherever possible, and ideally at corners or sidewalks that have enough clear space.
  - Standardize pick-up and drop-off conditions to allow loading to curb.



Other Implications for Self-Driving Vehicles

- Automatic door and ramp deployment needs to be addressed.
  - Treat each passenger similarly
  - Automate to passengers' preferences
  - Communicate deployment status to passenger
- Appropriate ramp storage is challenging, but possible.
- The pick-up and drop-off location ideally will be curb height but must have enough clearance to allow passengers to maneuver onto and off of the ramp easily.
  - E.g., Avoid deploying halfway onto a narrow sidewalk



SPONSOR

This presentation was funded in part by grants from the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) grant numbers H133E080019 and 90RE5011. NIDILRR is a Center within the Administration for Community Living (ACL), Department of Health and Human Services (HHS). The contents of this presentation do not necessarily represent the policy of NIDILRR, ACL, HHS, and you should not assume endorsement by the Federal Government.

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Center for Inclusive Design and Environmental Access
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QUESTIONS/ COMMENTS

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National Mobility Equipment Dealers Association (NMEDA)

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Kevin Frayne

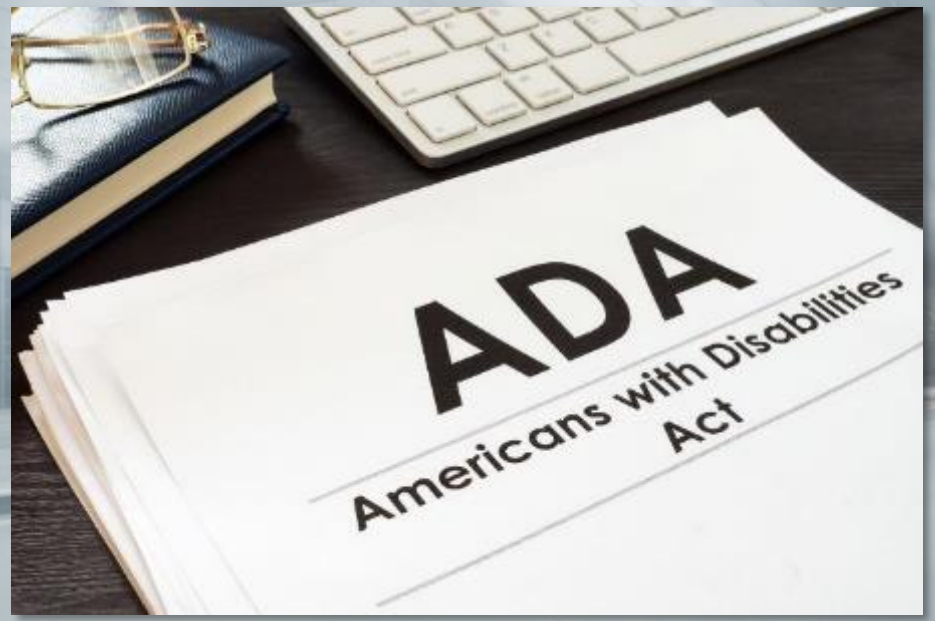
Director of Advanced Mobility Solutions

BraunAbility

BraunAbility

Accessible Transportation Milestones

1966



1990

202x

Topics

- Accessible AVs: Evolution or Revolution?
- A Geometry Refresher
- Autonomous = Electric = Batteries?

AVs: Evolution or Revolution?

- Autonomous vehicles are: (a) like today's vehicles; (b) reimagined transportation solutions; (c) electric; (d) privately owned; (e) shared; (f) multi-passenger public transportation; (g) all of the above.



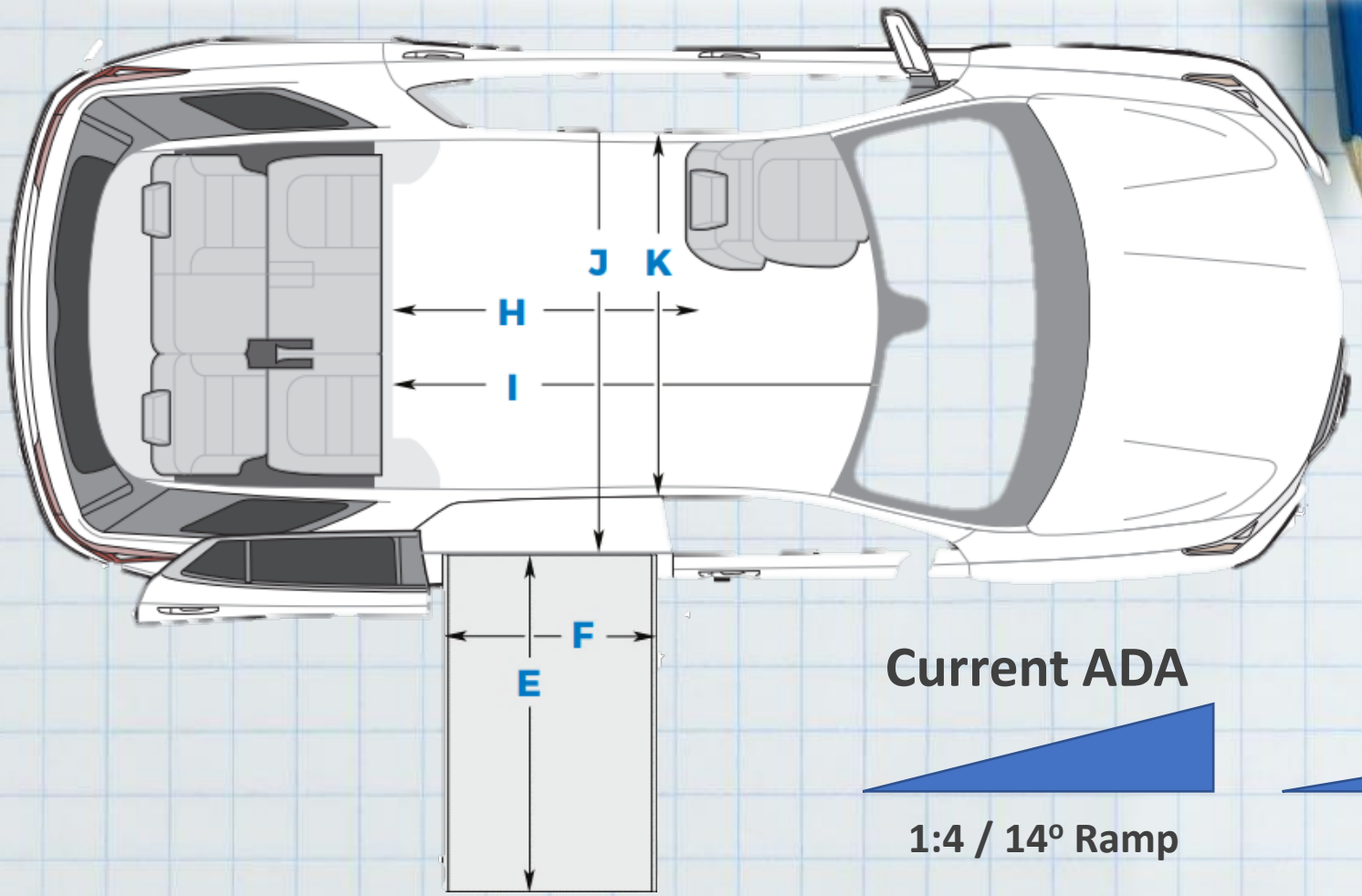



AVs: Are Everything

- (g) all of the above – and should be accessible

Entry / Exit = It's All About the Geometry

- Step-In: 10" / 250mm (or less) with kneeling is an "okay" place to be. 8" / 200mm is better.



Current ADA

1:4 / 14º Ramp

Proposed ADA

1:6 / 9.5º Ramp

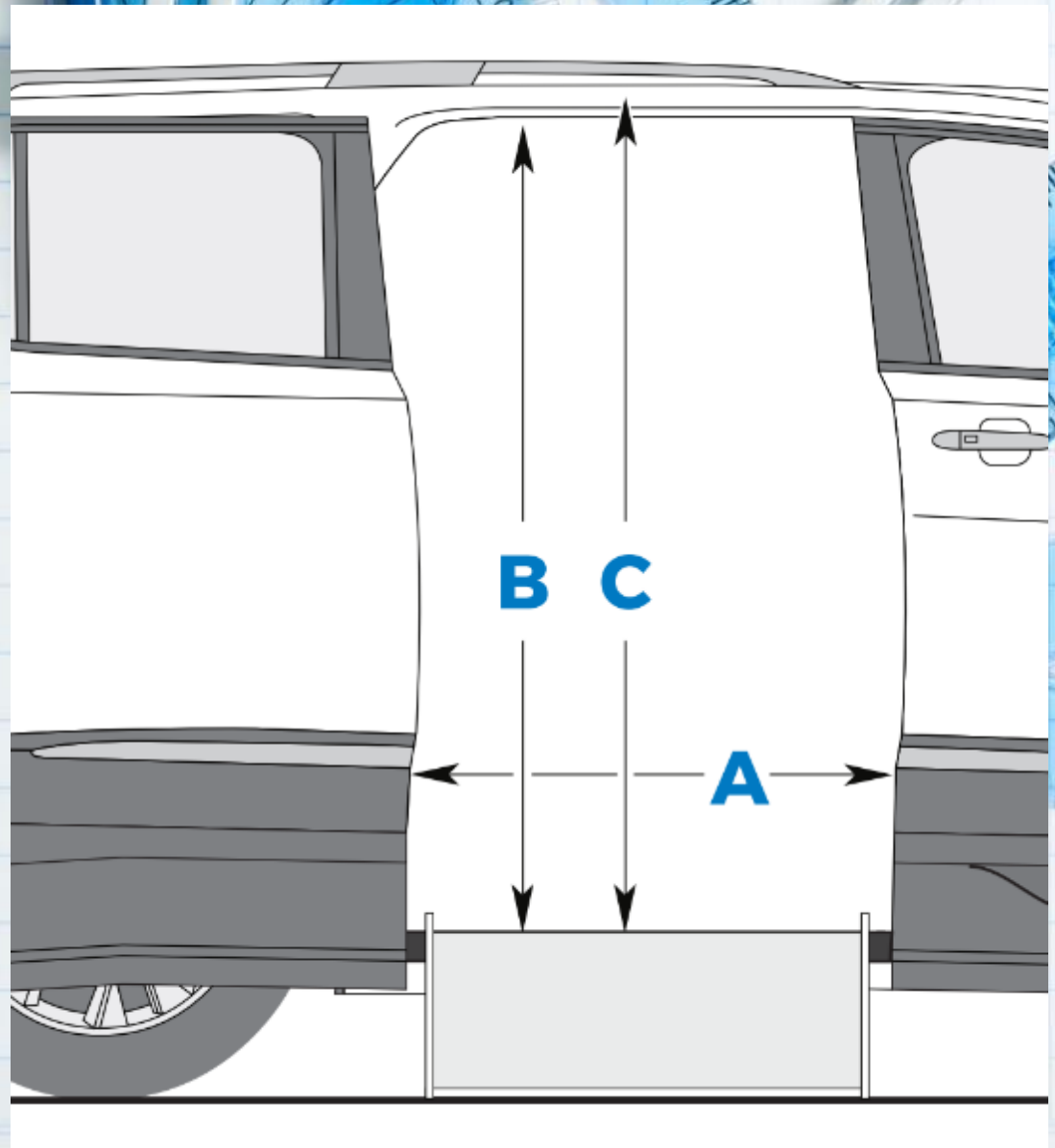
Step-In Height (w/kneeling) Drives the Solution

Lifts do not lend themselves as easily to full autonomous operation

Rarely do ramps and lifts compete for an application

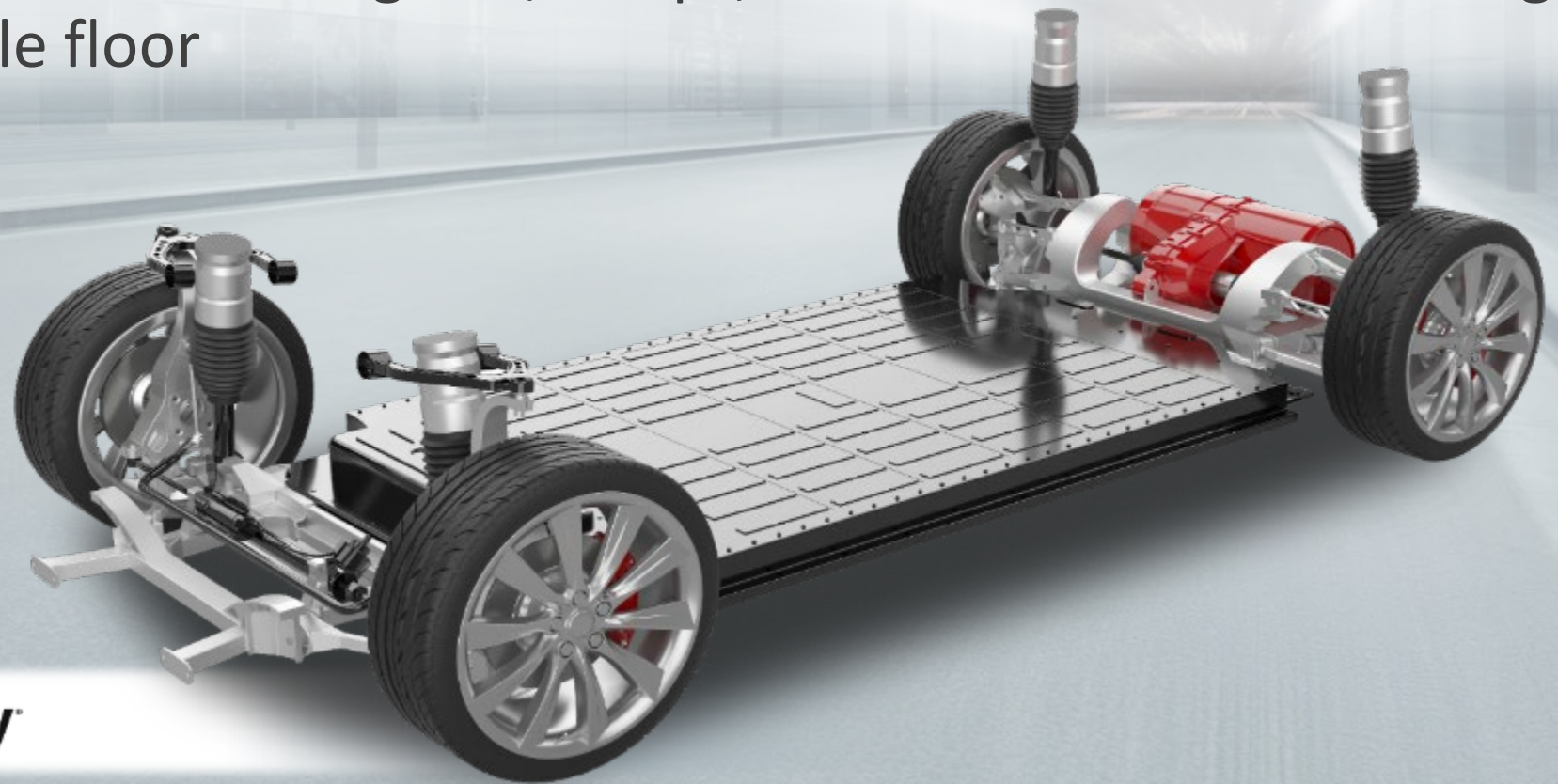
It's All About the Geometry

- Door Openings & Heights: Are greater than typically designed to for ambulatory usage
  - A: Door Width: ADA = 32" min.
  - B: Door Height: ADA = 56" min.
  - C: Interior Height: 59-61" min.



Batteries = New Challenges

- Underfloor batteries constrain entry/exit solutions
  - Sometimes structural, almost never moveable
  - Have integrated liquid cooling systems and other complexities
  - Precludes attaching lifts, ramps, and WC securement through the vehicle floor



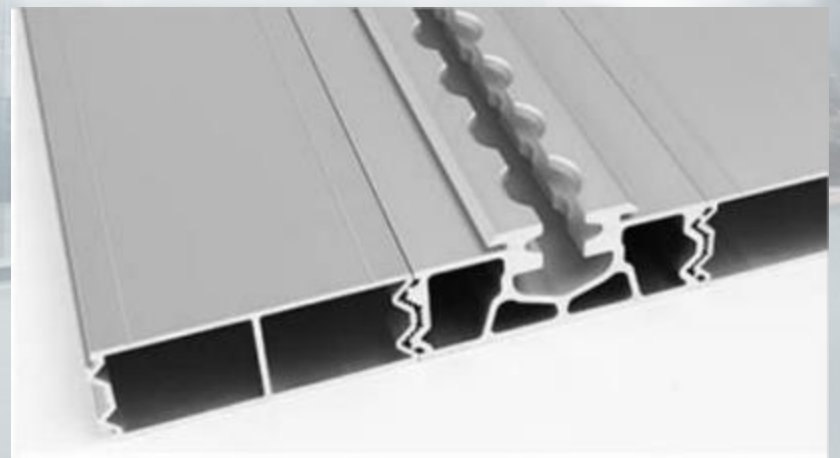
BraunAbility

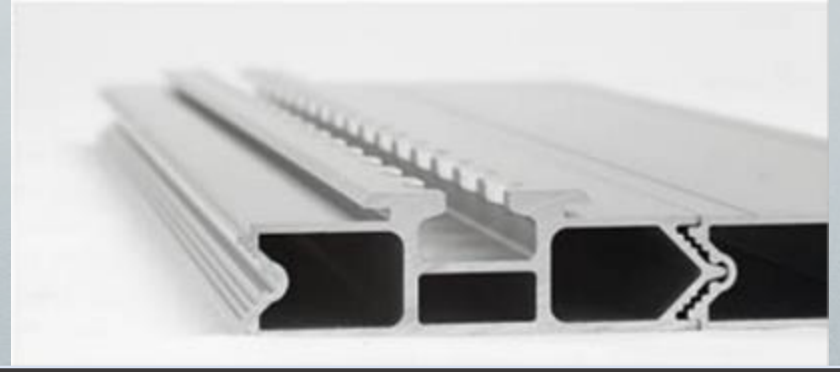
Batteries: Vehicle Accessibility Solutions

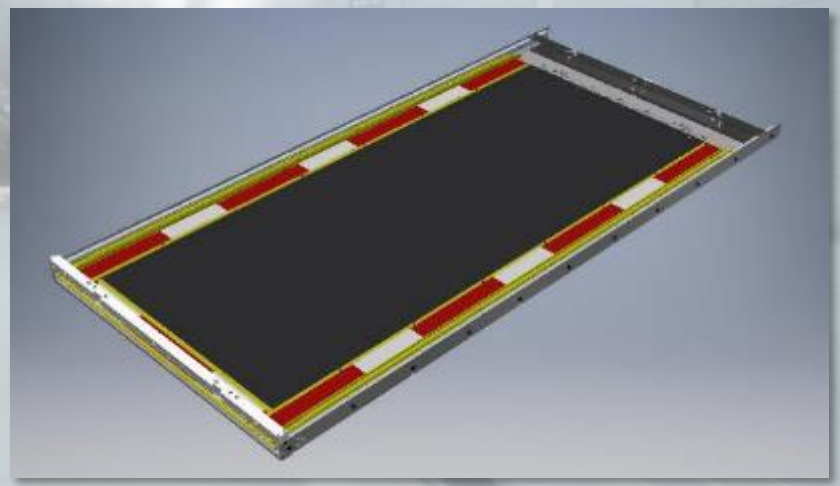
Go Above the Floor: On-floor fold-out ramp that attaches at the vehicle threshold.

Go On the Floor: Bonded (non-intrusive) flooring system that provides attachments for lifts, ramps, and WC securement solutions.

Go Below The Floor: 50mm slot (above batteries, below the floor) to accommodate an ultra-thin ADA ramp solution.





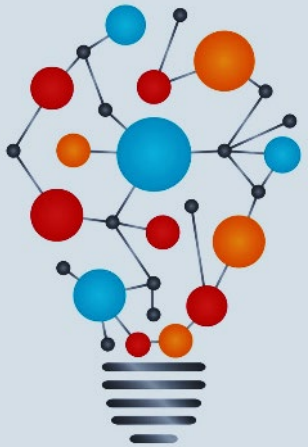


Evolutionary to Revolutionary Solutions

Summary:
AVs - An Accessibility Evolution and Revolution

- Innovate for the Now and the Later
  - 100% automated vs. 100% accessible: Don't wait for the first to do the second.
- Step-In is Critical: New EV architectures will severely limit their ability to accommodate ramp solutions if this is ignored
- AVs are EVs and have unique accessibility challenges (and solutions) due to batteries

Innovation



BraunAbility

BraunAbility Global Innovation Lab, Carmel, IN

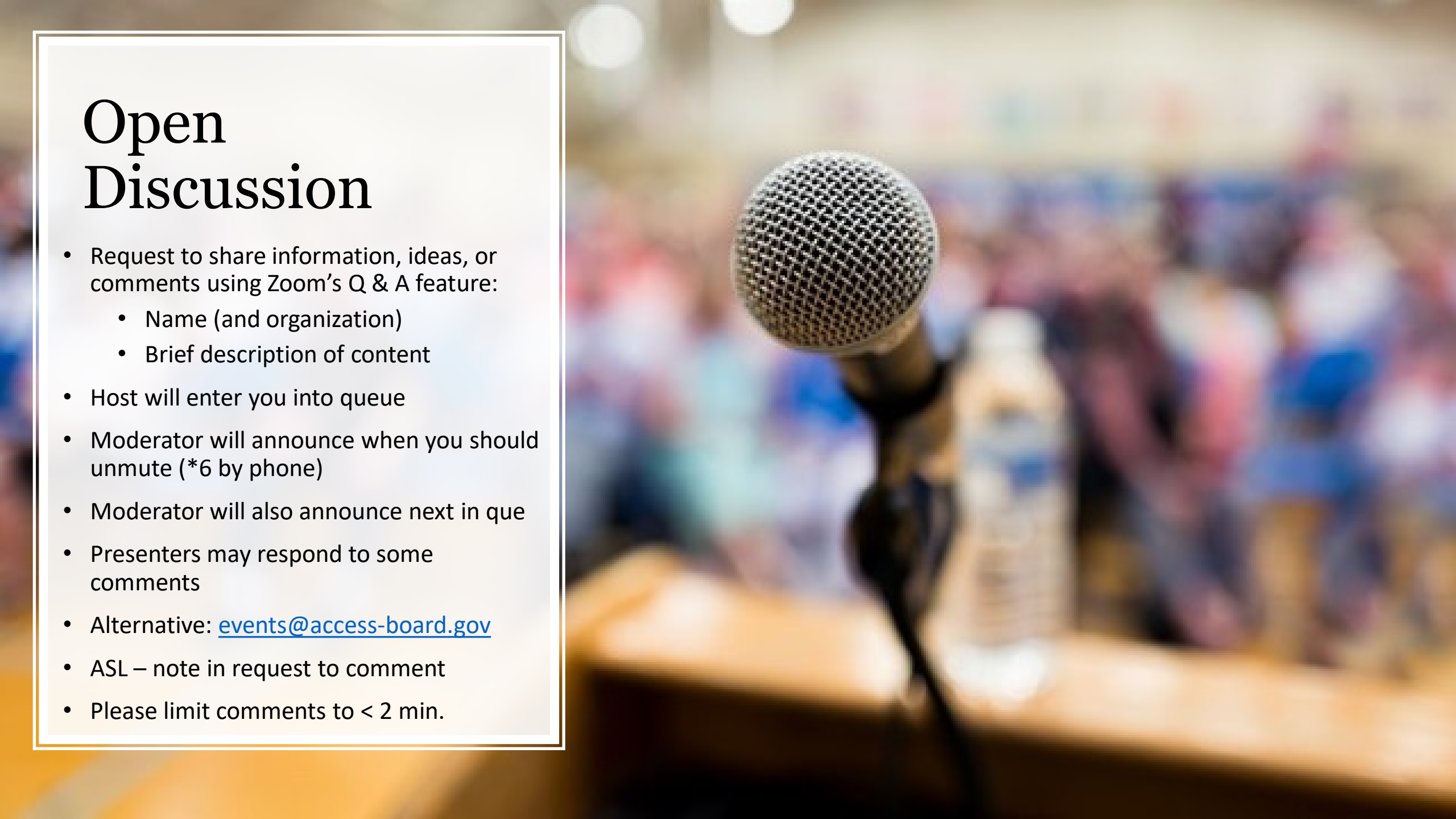
- Accelerate market-shaping innovation with a focus on EVs, AVs, sensing, IoT, etc.
- Purdue Autonomous Vehicle Accessibility project will be based here
- Opening April 1, 2021

BraunAbility

Questions?

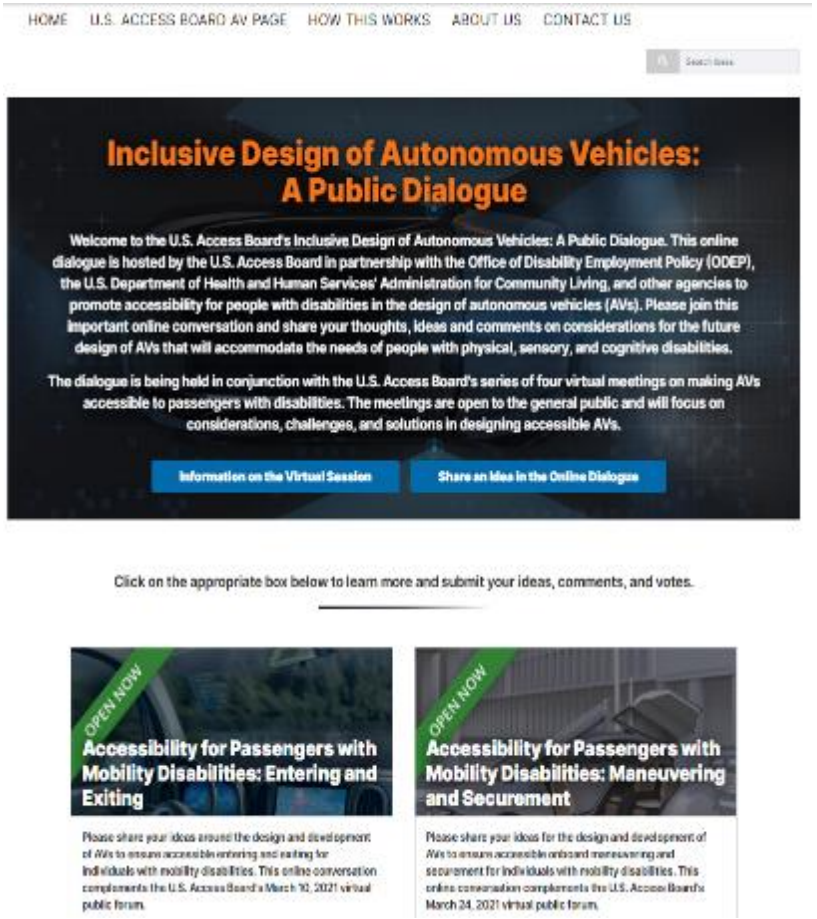
Open Discussion

- Request to share information, ideas, or comments using Zoom's Q & A feature:
  - Name (and organization)
  - Brief description of content
- Host will enter you into queue
- Moderator will announce when you should unmute (*6 by phone)
- Moderator will also announce next in que
- Presenters may respond to some comments
- Alternative: events@access-board.gov
- ASL – note in request to comment
- Please limit comments to < 2 min.



Online Dialogue

- Continue the conversation Online
  - https://transportationinnovation.ideascale.com/
  - Share ideas, comment, vote
  - For assistance, email: ePolicyWorks@dol.gov



Next Session

Accessibility for Passengers with Mobility Disabilities: Part 2

This session will address maneuvering and securement in vehicles and continued discussion of entering and exiting autonomous vehicles.

March 24, 2021, 2:00 – 3:30 (ET)

Welcome remarks by Jennifer Sheehy, Deputy Assistant Secretary of Office of Disability Employment Policy, Department of Labor.

Presenters:

- Scott Windley, U.S. Access Board
- Bryan Brillhart, Robotics Research
- Dr. Kathleen D. Klinich, University of Michigan
- Dr. Jordana Maisal, University at Buffalo

U.S. Access Board Meeting
4:00 – 5:00 ET

- Executive Director's Report
- Standing & Ad Hoc Committee Reports
- Election Assistance Commission
- New Business