

## Research Questions

1. How can we better conceptualize equity for transportation planning?
2. How does equity apply to advancements in automation technology?

## Introduction

- Equity is an emerging topic but a consensus on the meaning of equity is lacking within much of the existing literature reviewed for this study.
- In this project, we identify limitations in equity analyses and assess how equity has been analyzed within transportation engineering.
- Existing research concludes that AVs can enhance mobility while warning of potential dangers to disadvantaged subsets of the population, yet key details are missing within these findings.
- To address these limitations we propose a definition of equity to be applied to vehicle automation technology.
- Our definition facilitates establishing a framework to contextualize the effects of automation technology and encourages an enhanced and pragmatic understanding of equity implications related to each SAE automation level.

Table 1. SAE J3016 Levels of Driving Automation [1]

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You are driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
What do these features do?	These are driver support features			These are automated driving features		
	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met	This feature can drive the vehicle under all conditions	
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering OR • adaptive cruise control	• lane centering AND • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

## Traditional Equity Constructs and Definitions

- Horizontal equity is concerned with the treatment of comparable individuals [2]
- Vertical equity discusses impacts relative to a social hierarchy where disadvantaged individuals experience enhanced treatment [2]
- "No envy where 'no individual would prefer having the bundle of another'" [3]
- "The absence of avoidable or remediable differences" [4]
- "The fair, just, or other distribution of benefits and costs over members of society" [5]

## Findings

- The assertion that AVs can be both positive and negative is unhelpful and fails to provide insight into how to discern challenges within automation technology engendering inequity.
- Demographics, education, and physical attributes are all indicative of an individual's ability to perform the driving task. Vehicle features and capabilities can disenfranchise individuals based on characteristics which compose their overall identity. Furthermore, these attributes and characteristics may compound which can influence how disaffordances manifest within a population.
- The initial stages of where the vehicle monitors the driving environment in Level 3, where there is conditional automation, and Level 4, where there is high automation, have vast equity implications. The usability of automation technology is determined by how it is designed and deployed at these intermediate levels beyond economic and physical accessibility, which dictate when, where, and how geofencing barriers are drawn. Only after recognizing the needs and abilities of any potential user can automation technology work to advance equity.

## Equity Formulation

We define equity as: *The ongoing process of achieving equivalent usability of a given affordance through adjustment for difference while minimizing discriminatory disaffordances.*

- Affordances are provisions to provide functional possibilities [6]
- A disaffordance embodies problematic exclusionary practices which reduce ease, access, or usability [7]
- The goal within the equity definition proposed in this work is to promote equivalent usability of affordances within vehicles and automation technology by identifying features and technology with a potentially limited range of affordances, while navigating disaffordances and problematic exclusionary practices.

- Presumptions concerning the meaning and use of equity are informed by underlying values that are often undeclared and unexamined (fairness, morality, etc.)

## Results

### Application of Equity to Levels of Automation

#### Level 0: No latitudinal or longitudinal control features present

- If it were the case that individuals failed to be detected based on their height, weight, or size then it would be inequity.

#### Level 1: Latitudinal or longitudinal control feature present

- If it were the case that vehicle control features could not be used by a driver who is asymmetrically limbed then it would be inequity.

#### Level 2: Latitudinal and longitudinal control features present

- The discriminatory disaffordance in education or knowledge of vehicle capabilities can reduce usability of an affordance.
- If it were the case that a user did not utilize a vehicle control feature because of a failure to include, present, or convey the aspect of the vehicle then it would be inequity.

#### Level 3: Vehicle capable of operating under certain conditions

- If it were the case that head tracking monitoring systems incorrectly determined that some drivers were "nodding off" due to their size, mannerisms, or skin/eye color then it would be inequity.

#### Level 4: Vehicle capable of operating under all conditions specified in the Operational Design Domain

- We seek to refine this technology before widespread deployment.
- If it were the case that mobility options, such as walking paths and transit, existed at the fringes of geofenced areas then the enhanced transportation connectivity would advance equity.

#### Level 5: Vehicle capable of operating under all conditions

- We seek to prepare this technology for widespread deployment.
- With humans completely removed from the act of driving and vehicles providing transportation as a service, inclusive designs for body size, shape, and maneuverability are ways to increase usability and therefore advance equity.

- Equity is furthered by allowing an individual to utilize vehicle functions with equivalent usability physically, mentally, visually, or another aspect. The technology must adequately ensure anyone using a vehicle can have safe and accessible interactions.

## References

1. Society of Automotive Engineers. J3016\_202104: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. April 30, 2021. SAE International. [https://www.sae.org/standards/content/j3016\\_202104](https://www.sae.org/standards/content/j3016_202104).
2. Litman, T. Evaluating transportation equity. World Transport Policy & Practice, Vol. 8, No. 2, pp. 50-65.
3. Kolm, S.C. Justice et équité (Justice and equity). MIT Press, Cambridge, Massachusetts, 1972.
4. Davis, A., and P. Pilkington. A Public Health Approach to Assessing Road Safety Equity - The RoSE Cycle. June 1, 2019. <https://uwe-repository.worktribe.com/output/846233/a-public-health-approach-to-assessing-road-safety-equity-the-rose-cycle>. Accessed April 7, 2023.
5. Miller, D. Principles of Social Justice. Harvard University Press, New York, 2001.
6. Heft, H. An Ecological Approach to Psychology. Review of General Psychology, Vol. 17, No. 2, 2013, pp. 162-167. <https://doi.org/10.1037/a0032928>.
7. Wittkower, D. E. Principles of Anti-Discriminatory Design. Presented at the 2016 IEEE International Symposium on Ethics in Engineering, Science and Technology (ETHICS), 2016.

## Acknowledgments

Thank you to Ford Motor Company for sponsoring this research as a private partner.

## Next Steps

- This equity formulation will be applied to existing transportation systems to analyze current instances of inequity in transportation.
- This research will employ surveys and focus groups to better understand how individuals perceive and use automation technology.
- This research will explore safety benefits from automation technology that vehicle users achieve or fail to realize.
- Future research can expand upon this equity definition to further an understanding of equity within transportation and ensure future design and planning efforts direct attention to better serving historically disadvantaged communities.