DOI: http://doi.org/10.12795/Argumentos/2024.i27.06

AUTONOMOUS VEHICLES AND RIGHTS OF PERSONS WITH DISABILITIES: RISKS AND OPPORTUNITIES FOR AN EQUITABLE TRANSPORTATION SYSTEM

VEHÍCULOS AUTÓNOMOS Y DERECHOS DE LAS PERSONAS CON DISCAPACIDAD: RIESGOS Y OPORTUNIDADES PARA UN SISTEMA DE TRANSPORTE EQUITATIVO

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RECIBIDO: 06/09/2024
ACEPTADO: 15/11/2024

Abstract: People with disabilities face a number of barriers to personal mobility, and creating an equitable transportation system is one of the challenges that can promote social inclusion. Autonomous vehicles can be a solution to this problem. This article explores the relationship between equitable transportation and social equality, highlighting the opportunities and risks that exist for different groups of people with disabilities and functional diversity, including people who have difficulty driving due to age. It also discusses how different groups perceive autonomous vehicles. The conclusions provide recommendations for the establishment of real and effective policies for equitable transportation and for the industry to incorporate universal design patterns. It also highlights the need for disability organizations to be proactive in constructive dialogue with governments and industry.
Keywords: Persons with disabilities; autonomous vehicles; accessible design; accessibility; transportation equity.

Resumen: Las personas con discapacidad se enfrentan a una serie de barreras a su movilidad personal, y la creación de un sistema de transporte equitativo es uno de los desafíos que pueden favorecer la integración social. Los vehículos autónomos pueden ser una solución a este problema. En este artículo se explora la relación entre transporte equitativo y equidad social, mostrando las posibilidades y los

riesgos que existen para los diferentes colectivos de personas con discapacidad y diversidad funcional, incluyendo las personas que por razones de edad tienen dificultades para conducir un vehículo. Se discute también la percepción que los diferentes colectivos tienen en relación con los vehículos autónomos. En las conclusiones se ofrecen recomendaciones para el establecimiento de una política real y efectiva de transporte equitativo, y para que la industria de la automoción incorpore patrones de diseño universal. Igualmente, se destaca la necesidad de que las asociaciones de personas con discapacidad sean agentes proactivos en un diálogo constructivo con gobiernos e industrias.
Palabras clave: personas con discapacidad; vehículos autónomos; diseño accesible; accesibilidad; transporte equitativo.

Introduction: equitable transport and social equality. State of the art

Mobility is the ability to move from one place to another. It has to do with a person's freedom and ability to be the owner of his or her own body and to decide where he or she wants to be. It is therefore a question of physical autonomy, which makes it possible to transform abilities into life projects. By inclusive mobility, we mean the movement of people with disabilities or special needs that prevent or limit the exercise of the right to mobility. A *transportation system* can be defined as "the combination of elements and their interactions, which produce the demand for travel within a given area and the supply of transportation services to satisfy this demand" (Cascetta, 2001, p. 1). When we speak of equitable transportation, we are referring to the need for technology to provide these groups with the necessary means so that this right to mobility ceases to be a theoretical right and can be put into practice.

People with disabilities face a number of barriers to personal mobility, and creating an equitable transportation system is one of the challenges that can promote social inclusion. Autonomous

vehicles can be a solution to this problem. Some figures give us an idea of the scale of the problem. It is estimated that between 10 and 20 percent of the adult population in the United States cannot drive a car due to physical reasons, age, or financial issues (Litman, 2017). On the other hand, approximately 1 billion people, or 15% of the world's population, have some form of disability (WHO, 2018b). Given the cultural characteristics of the United States, including dependence on the automobile, public transportation options for these groups are very limited in most urban areas and virtually all rural areas. Lack of access to one's own vehicle is in itself a factor of social discrimination, except in a very limited number of large cities where public transportation is more convenient. In this case, the mobility of persons with disabilities also depends on transport companies with adapted vehicles. Mobility options also become another accessibility gap, as one third of the population with special needs in the United States faces problems of inadequate access to transportation, with reduced access to jobs and reduced quality of life (Taylor et al., 2010).

According to the Ruderman Foundation White Paper (Claypool et al., 2017), one of the reference documents on this topic, one in five people in the United States, more than 57 million in total, have a disability. Of these, 6 million people have difficulty meeting their personal transportation needs. For this group, transportation is a key service that must be community-based to enable them to fulfill their civic responsibilities and enjoy their civil rights. The moment a disability limits transportation options, it automatically translates into reduced economic and employment opportunities, a significant decrease in quality of life, and a sense of isolation and loneliness that has a negative impact on health, leading in many cases to depression. Therefore, using autonomous vehicles to reduce the barriers faced by people with disabilities would enable new employment opportunities for two million people with disabilities (according to

2017 estimates) and a net savings of $19 billion in healthcare costs due to missed medical appointments. The report notes that there would be a global impact of $1.3 trillion in savings from increased productivity, reduced pollution, reduced fuel consumption, and reduced medical costs due to fewer traffic accidents. For people with disabilities, on-demand mobility solutions offer great potential for reducing mobility barriers. In order to shape and implement the parameters of this revolution, the associations concerned need to organize themselves, learn more about this technology, and increase their social participation efforts.

A more recent report published by the National Disability Institute on December 30, 2022 (Modicamore, 2022; Gonzales, 2023) notes that the lack of adequate transportation is a challenge for people with disabilities seeking employment, contributing to an unemployment rate in the United States that is twice that of people without disabilities. This report provides more recent figures. Mass deployment of affordable and reliable autonomous vehicles would mean an increase of 9.2 million jobs in U.S. income taxes, Social Security, and import tariffs. It would also reduce spending on the Social Security program for people with disabilities by $28 billion. As a result, it would be highly beneficial to millions of families, both macroeconomically and economically, and would have a significant impact on removing a critical barrier to employment for millions of people with disabilities.

Definitions and concepts related to autonomous vehicles and equitable transportation

An autonomous vehicle by definition is one that does not require human intervention to drive on public roads, where pedestrians and cyclists, as well as other users of conventional vehicles, also

circulate. These vehicles are equipped with task automation systems that fully or partially replace a driver in the so-called *dynamic driving task*, i.e., driving under real-world conditions in which risk situations may arise that require appropriate decision-making. These task automation systems receive information from a set of highly complex and highly coupled sensors and subsystems: infrared sensors, ultrasonic sensors, inertial systems, geopositioning and satellite navigation systems, artificial vision and signal recognition systems, radar systems, systems for recognizing safety distance with respect to other vehicles, etc. Autonomous vehicles have six categories or levels depending on the degree of intervention of these automatic human driving assistance systems. These levels of automation have been standardized by a global body, the *Society of Automotive Engineers*, according to the role played in dynamic driving tasks in normal situations or in emergency situations by each of the three main agents: the driving automation system, the person in charge of driving and other systems and components of the vehicle. Five levels of automation are therefore distinguished (Km77, 2022; SAE, 2022, apud Bustamante, 2022):

- **Level 0**: No level of automation, where driving is completely manual with no assistance for vehicle control during dynamic driving.
- **Level 1**: Driving assisted by devices that can control the vehicle longitudinally or laterally, but not both at the same time. For example, cruise control or parking assist.
- **Level 2**: Partial automation of dynamic driving. Partial assistance on both axles at the same time, but always with the possibility of disengaging the system so that the driver can regain control if necessary. In this way, the driver is ultimately responsible for responding to the detection of unforeseen hazards or other emergency situations. For

example, the system recognizes road markings and keeps the driver in his or her lane, assists with driving in traffic jams, and automatically brakes if there is a risk of a collision with the vehicle in front.

- **Level 3**: Conditional driving automation. The driver can relinquish control to the automatic system, but can deactivate the system at will in the event of a risk or emergency situation. If the system detects conditions or elements for which it does not have an appropriate response, it alerts the driver to reassume control.
- **Level 4:** High level of driving automation. The vehicle drives in automatic mode at all times by default, without expecting any intervention from the driver. The system is ready to react to unforeseen dangerous situations and choose the most appropriate action, i.e., the one that favors the so-called minimum risk situation. The person in charge can always request to regain control of the vehicle if he/she deems it appropriate, although the vehicle may not respond immediately. If it is the vehicle that requests the driver to regain control and the driver fails to do so, the system can stop the vehicle in a safe area and move it off the road.
- **Level 5:** Full driving automation. The Automated Driving System (ADS) allows the vehicle to drive on any route that can be driven by a person in charge of driving, and is able to withstand the same environmental conditions, including adverse weather conditions. It is therefore not necessary for the vehicle to have a steering wheel or accelerator and brake

pedals, as the vehicle's automatic system takes care of its own driving.

Implications of the use of autonomous vehicles for people with visual impairments

A study by Fink et al. (2021) points out that despite the promise that autonomous vehicles hold for the future of accessible mobility, the policy landscape guiding the development of these vehicles does not take into account the needs of certain groups with significant limitations in the use of all modes of transportation, particularly blind and visually impaired people and adults with age-related vision problems. It is still a challenge to design legal ecosystems that pay special attention to these groups. For these regulatory frameworks to be truly inclusive, special attention must be paid to the perceptions, needs, and concerns of visually impaired people regarding autonomous vehicles. In the United States, 27 million adults, nearly one-tenth of the population over the age of 18, have some degree of visual impairment, and other reliable statistics put the number of people with some form of visual impairment worldwide at 2.2 billion (WHO, 2019). Since visual impairment often limits the ability to obtain a driver's license, these figures suggest that at least 25 million people in the United States and 253 million worldwide could benefit from the new mobility opportunities offered by autonomous vehicles. These benefits would have a greater impact here than on any other group in terms of promoting greater independence, access to employment, economic stability, physical and mental health, access to leisure activities, and general enjoyment of life. In short, a very significant increase in the quality of life for people with varying degrees of visual impairment.

Regarding perceptions of the role these vehicles can play, the opportunities they open up, and the risks they pose, a study conducted in 2020 (Brinkley et al.) with blind and visually impaired people found that a large majority of respondents (89%) had a positive opinion of autonomous vehicles (50% very positive, 30% moderately positive, almost 8% slightly positive). More than 90% expressed interest in owning such a vehicle. However, 24% were concerned about laws preventing a visually impaired person from driving an autonomous vehicle. Fifty percent felt that the individual needs of the visually impaired are not considered in vehicle design in general, although they were more confident that this would not be the case with autonomous vehicles. While 37% of respondents were confident that the technology already exists to address accessibility issues, they also had other concerns about the location and orientation of the vehicle while driving. Fifty-three percent emphasized the importance of being able to correctly verify stated destinations. They also expressed interest in the development of tools to locate the vehicle in congested areas, parking guidance, and real-time vehicle status information during the trip.

Another aspect of particular importance to this group is the development of interfaces based on the use of mobile phones, as many of the participants in this research highlighted their desire to use the accessibility features of their mobile phones to control an autonomous vehicle. A significant majority (71%) chose dictation as their first interaction interface, although they expressed concerns about the reliability of dictation, as speech recognition accuracy is not 100%, and also about the potential drain on cell phone batteries. They also mentioned the potential of in-car touchscreens as an alternative form of interaction. However, there was a downside to this perception, as many participants pointed out the lack of accessibility of current touchscreens, even those with text-to-speech interfaces. One way to solve this problem would be to incorporate

tactile maps that update in real time so that blind passengers can know the location and orientation of the vehicle at all times.

Many visually impaired users prefer large font displays to audio interfaces. On the other hand, people with hearing impairments need visual information, while people with limited dexterity or mobility need to be able to reach and manipulate controls. In short, there is a need for different types of interfaces that are easy to understand and use, and that can also benefit adults who are not always comfortable with technology. We should think of a trip in an autonomous vehicle as including communication with the vehicle, locating it, getting in, getting out, finding the final destination, and other steps such as overcoming architectural obstacles when arriving at the final destination. For visually impaired people, the use of applications integrated into their mobile phones can facilitate some of the steps that currently require the accompaniment of another person. When the final destination is reached, it is usually the person in charge of driving who indicates that the destination has been reached. There are also people who, because of their age, need guidance or physical assistance from door to door. In the real world, autonomous vehicles will need to pick up the person at a location where there are no physical barriers that might prevent a door from opening, or where there is a ramp for a wheelchair. Again, communication via mobile phone applications can help the vehicle's automated systems identify the most suitable access points that avoid architectural barriers, and also advise the user to move locally to facilitate access through these more convenient points.

It is also important for autonomous vehicles to be equipped with cameras and audio-visual communication to provide assistance in emergency situations or to monitor people with mental or emotional disabilities. In these situations, a sense of security is essential for the user. Even if the system is not in constant use, it is very important for the vehicle user to know that these emergency assistance systems

are always at his or her disposal (Dicciano et al., 2021; Bayless and Davidson, 2019). Here, a new dilemma between security and personal privacy appears, and some organizations have shown their concern about the privacy of the vehicle occupants and also about the use of personal data generated during the trip, such as conversations or any physical act that may be recorded by the vehicle's cameras and sensors. It is true that these data can help to better adapt vehicles to the needs of users with disabilities and their companions, but it also requires a strict zeal to ensure that the information collected is the minimum necessary and is always used for ethical purposes, previously declared and transparent to the person concerned, especially in the case of people with a mental or emotional disability that requires continuous monitoring for health reasons. It will be necessary to clearly define who has access to this information in real time, who has subsequent access to the information recorded, and what care services are available to respond to contingencies that arise during the trip. For example, consider the possibility of an epileptic seizure during the trip, or how to deal with a passenger's anxiety crisis.

Another source of concern for the visually impaired is the algorithms that govern the behavior of autonomous vehicles in the event of an unavoidable collision, always ensuring that the life of a disabled person is no less valuable than that of a non-disabled person. Algorithms must also be able to recognize people who may take longer to cross a crosswalk because they have a guide dog, use a white cane, use a wheelchair, or have other mobility issues, and therefore may be more likely to be hit by an autonomous vehicle that has not been programmed to account for these possibilities.

While many older people feel more comfortable in an autonomous vehicle in which they are simply passengers, the opposite is true for blind people. As evidence of this, research conducted by a team at Virginia Tech in collaboration with the

National Federation of the Blind in the United States showed that a significant number of potential users were more interested in autonomous vehicles with interfaces that would allow a visually impaired person to exercise executive control functions, rather than simply riding passively as a passenger in an autonomous vehicle (Hong, 2010).

In its conclusions, the study by Fink et al. (2021) highlights, in addition to a more positive attitude towards autonomous vehicles on the part of visually impaired people, the importance that interaction through mobile phone-based applications seems to have for this group, which should be a fundamental requirement for the universal design of autonomous vehicles in the near future. Other needs of this group should also be considered, such as the consideration of guide dogs as full users of autonomous vehicle services. As an anecdote, one of the co-authors of this study experienced first-hand the discrimination of current transportation for people with visual impairments, as the vehicle he rented did not accept his guide dog on a trip to the local airport, causing both of them to miss their flight. The new legal framework to be established must guarantee access for blind people and their guide dogs to all modes of transport if we are to achieve a truly equitable mobility system.

The perception of autonomous vehicles by people with disabilities: fears and hopes

As Stine (2023) points out, autonomous vehicles promise increased mobility and new opportunities for people with disabilities. They will also provide greater access to employment, social services, or simply mobility to get out of the house, especially in rural areas[1].

[1] The *goMARTI* project, an acronym for *Minnesota's Autonomous Rural Transit*

However, there are also design issues that can pose a significant risk of the discriminatory biases that are often present in industrial design. We have already discussed how some of these biases relate to human behaviors around transportation that are stereotyped according to statistical models that ignore individual cases. We have already noted that some biases that pose a threat to people with disabilities have to do with the programming of artificial intelligence sensors in autonomous vehicles that are designed to detect standard pedestrians, who typically cross the street only in predictable places, such as crosswalks. However, as we mentioned earlier, such sensors may not be designed to detect non-standard cases of wheelchair users or blind people walking with a guide dog or using a cane. In many cases, the presence of curbs or other architectural barriers may force people to cross the street in places where there is no crosswalk, with the added danger that it may be difficult to program the vehicle's visual detection sensors to act properly in this type of situation. The problem for pedestrians with functional diversity (which we

Initiative, is a prime example of these new opportunities for people with disabilities. The project began in 2021 and has $13 million in federal and local funding through spring 2027. Its goal is to provide a transportation alternative for people with disabilities in rural areas, where the shortage of drivers for adapted vehicles is particularly acute. The project uses Toyota minivans equipped with an automated driving system to provide free rides that can be booked by phone or through a mobile app. Each vehicle has an operator to help with access maneuvers, especially if the person using the vehicle is in a wheelchair. This operator sits in the driver's seat and has a button to take control of the vehicle in the event of an emergency. A computer maintains control of the vehicle 90 percent of the time. Driving in rural areas is not the same as driving in urban areas, but the system is designed to learn from experience and facilitate on-demand routes to pre-determined off-road locations. By the end of December 2023, the project had provided more than 5,000 services in the region without a single accident. Other rural experiments are underway in states such as Iowa and Ohio, and it is common to see autonomous vehicles operating on an experimental basis in cities such as San Francisco (Government Technology, 2023).

ironically call non-standard to simplify computational models) is greater when we consider the gradual replacement of internal combustion vehicles by electric vehicles. Electric vehicles are by nature much quieter than conventional vehicles, which makes them more difficult to perceive when approaching from the side. This problem, which is serious for the entire population, is particularly serious for the visually impaired. To avoid this, some automakers have introduced systems that artificially create the sound of an internal combustion engine in urban environments, making it easier for pedestrians to detect the vehicle's presence. The combination of an autonomous vehicle that is also electric can increase the risk of accidents, since at an automatic driving level we do not have a human element to push the button to avoid running over pedestrians who, for whatever reason, have not perceived the presence of the vehicle.

Technical solutions to these problems have led to frustration in the disability community because many automakers do not consider their needs when designing their vehicles. Adaptation to special needs occurs after the vehicle has been designed, tested, and put on the market, which means that people with disabilities who purchase them must retrofit the vehicles, resulting in increased costs and often ineffective adaptation. Some companies, such as Volkswagen, have changed this philosophy and integrate inclusive mobility teams that work with disability organizations (Stine, 2023). Other companies, such as Cruise, Waymo, and Toyota, are also presenting technical solutions for transporting people with functional diversity and special needs. It is possible that these initiatives are not the result of an ethical reflection or a genuine interest in the group of people with disabilities, but of the recognition of the importance of this group in the United States, where about 57 million people have a disability and where the unemployment rate of this group is twice that of the non-disabled population. It is also estimated that the generalization

of autonomous vehicles would mean the integration into the labor market of 2 million people with disabilities who are currently outside the labor market due to the lack of opportunities for inclusive mobility or, as we prefer to call it in this article, *equitable transportation*.

Another perceived problem with autonomous vehicles has to do with decision making in autonomous vehicles and game theory. This is the old hypothetical problem of the *unbraked streetcar* (Thompson, 1985): an unbraked streetcar approaches a group of five people on the main track and will kill them if we do nothing. However, if we activate the switch, only one person will die on the siding to which we would direct the streetcar. This case reflects the ethical dilemma of whether a decision that chooses a lesser evil over a greater evil is itself ethical. Autonomous vehicles have revived this problem because they must be programmed to make decisions with ethical consequences in situations where a choice must be made between two decisions that inevitably involve harm, but to different degrees (Radun et al., 2019). For example, an autonomous car must automatically swerve to avoid hitting a pedestrian, even if this means hitting an obstacle with fatal consequences for the car's occupants. Nor is it the same if there is only one driver in such a vehicle, or if there are other passengers traveling with the vehicle who are members of the driver's own family. It is interesting to note that recent studies suggest that most people would approve of autonomous cars that follow the parameters of a utilitarian ethic and divert their trajectory to avoid a greater evil, even though it puts their occupants at risk. At the same time, however, they say they would prefer to buy autonomous vehicles that prioritize the protection of their occupants. This contradiction is very strange, since what is perceived as beneficial for the common good is not what each person would choose for themselves and their family (Guevara 2021; Bonnefon et al., 2017). Ultimately, the application of utilitarian

criteria in the programming of autonomous vehicles has the effect of increasing the number of traffic accidents that could be avoided, as people would be reluctant to buy a technology that they admit is much safer (Bustamante, 2022).

Although the introduction of equitable transportation criteria through the popularization of autonomous vehicles may represent a revolution in personal mobility, its successful implementation requires acceptance by the groups involved. Bennet et el (2019) conduct the first academic study on the perception of autonomous vehicles by people with physical disabilities that affect their mobility. The reliability of this study is based on a significant sample of British participants, with a methodology based on a response analysis using a structural topic mobilization (STM) procedure. The results were tabulated following a structural equation model (SEM) designed to understand the attitudes of physically disabled people towards travel in driverless vehicles.

The positive factors of the introduction of autonomous vehicles, according to the scientific literature, are the following: decrease in the number of accidents (WHO, 2018a), decrease in environmental pollution (Herrmann et al. 2018), possibility of using the trip to perform professional tasks, sleep, watch television, read a book or the press, or consult the mobile phone (Hulse et al., 2018). Negative factors are: concern for pedestrian safety and irresponsible behavior of conventional vehicle drivers (Konig and Neumayr, 2017), risk of vehicle software failure (Henderson and Golden, 2015), and loss of personal control over events in compromised situations (Howard and Dai, 2014).

The attitudes of the disabled group differed significantly from those of the non-disabled group. The most significant variables influencing the attitudes of the first group were interest in new technologies, level of disability, prior knowledge of autonomous vehicles, and change in control. Their greatest fears were related to

the safety issues of autonomous vehicles, such as those discussed at the beginning of this section, while the concerns of the nondisabled group were more related to road conditions and the poor behavior and mistakes of drivers of conventional vehicles. The most negative attitudes came from the non-disabled, with nearly 80% of respondents expressing significant reservations and doubts about the goodness of autonomous vehicles. Bennet et al. draw several conclusions from this study. One of them is that there is a generalized fear that needs to be addressed in order to change the attitudes of people with disabilities towards autonomous vehicles. To this end, an information policy must be developed to make this group aware of the benefits of autonomous vehicles for their personal autonomy. Public authorities must develop infrastructure and traffic regulation policies that facilitate the introduction of autonomous vehicles and guarantee the safety of their use, while vehicle manufacturers must take into account the enormous importance of the group of people with disabilities and make them active participants in the design and development process of new vehicles, instead of missing a new opportunity for social integration at a global level (Bennett, 2019).

In another field study, this time in the United States, Kassens-Noor et al. (2021) analyzed the perceptions, concerns, and willingness to use an autonomous public transportation system among a sample of 1861 Michigan bus riders with special needs. They found that in this case, respondents with special needs perceived autonomous vehicles from a mostly negative perspective, especially among mobility-impaired groups. Compared to the nondisabled population, special needs riders of various types were more concerned about safety issues, while mobility-impaired respondents were more likely to be wary of autonomous vehicle technology. People with visual impairments were more likely to be interested in an autonomous bus system. The authors' conclusion highlights the need to properly understand how different groups of

people with special needs perceive the issue of autonomous vehicles in very different ways, which means that a one-size-fits-all policy that does not take into account the significant differences between these groups may result in greater inequality. The diversity of special needs or disabilities requires different vehicles, different outreach and communication strategies, and different responses to the mobility needs of each group. For this reason, it is necessary the commitment of involvement of the administration with the different associations of people with disabilities or special needs for the design of strategies for the implementation of an autonomous transport that offers improved mobility and accessibility. In short, these two studies available to us highlight that, despite the recent attention given to the problem of equitable transportation, the group of people with special needs is still far from the academic research on social perceptions of autonomous vehicles.

Functional diversity of persons with disabilities: Recommendations for equitable transportation policy

As Dicciano et al. (2021) point out, people with disabilities are a diverse group, and accessibility and usability solutions for autonomous vehicles must be tailored to the needs, circumstances, and preferences of each group. To identify such needs, more participatory action-engineering design studies and new high-quality prospective experimental studies should be promoted to assess the consequences of accessible and usable autonomous vehicle technology. These studies should consider not only the technical characteristics of autonomous vehicles, but also the entire transportation pathway as an ecosystem that should be designed using universal design parameters to accommodate the functional diversity of people with disabilities and special needs.

According to the Ruderman report (Claypool et al. 2017), there is no guarantee that autonomous vehicles will be accessible to the disability community from the start. There are many historical examples of technologies that did not take their needs and aspirations into account when they were designed. For example, the pioneers of the Web did not consider equal access to the Internet for blind and deaf people, and many people with disabilities have faced, and continue to face, unnecessary barriers to accessing information. Restrictive policies can also affect equal access to autonomous vehicles. For example, one of the most important debates surrounding the regulation of these vehicles is whether a driver's license should be required to use them. Many people with severe disabilities, whether due to blindness, epilepsy, intellectual disability, or other physical limitations, could benefit from autonomous vehicles but are not considered qualified to hold a driver's license. On the other hand, the spectrum of people with disabilities presents a wide variety of needs, preferences, and requirements when it comes to transportation. It will therefore be imperative to involve the relevant associations in the development of public policies.

Given the wide range of functional diversity, it is almost impossible to design a vehicle that can be adapted to all members of the disabled community. From the technology developer's point of view, there is a growing awareness on the part of car manufacturers of the need to incorporate universal design parameters into their products, avoiding the need to adapt specialized designs *a posteriori*. Dicciano et al (2021) point out that one of the main barriers to accessible mobility is the perception that in order to drive an adapted vehicle, adaptations to previously purchased vehicles must be made by another company, and these adaptations are in many cases as costly as the cost of the vehicle itself. Following universal design guidelines, every vehicle should have a flexible interface that can be

selected by the user based on his or her personal needs, by voice command, or simply by pressing a button. It is much easier to fight for the incorporation of mechanisms that guarantee accessibility in the first moment of design than to fight later for multiple adaptations that in many cases are difficult or costly to implement. A number of recommendations can be derived from this argument.

Recommendations for the disability community: The disability community should begin to fully engage in the autonomous vehicle debate by building a coalition of aligned interests. Second, this coalition should evaluate and evaluate the technical issues involved in the design, testing, and development of autonomous vehicles. Third, this coalition should evaluate and propose a research agenda that would encourage consideration of the needs and challenges of transportation for people with disabilities. The result should be a set of recommendations for the successful implementation of universal design in current and future transportation systems.

Recommendations for government: Vehicles with high levels of automation should not require a driver's license. While it is true that under current conditions it is still reasonable to require a driver's license, the profound technological change that autonomous vehicles will bring will require a revision of the regulatory paradigm. Level 4 or 5 autonomous vehicles have safety systems that could eliminate a large portion of the world's traffic accidents. In the United States alone, there are more than 6 million accidents per year. Since the vehicle is actually the driver and not the person in the vehicle, there is no need for a person to be in control of the vehicle. These benefits should also apply to the elderly, who are finding it increasingly difficult to renew their driver's licenses. For these people, it also opens up a wide range of possibilities for gaining autonomy and quality of life.

Recommendations for industry. Automakers should also emphasize the design of Level 4 and 5 vehicles by conducting pilot

projects for groups of people with disabilities and the elderly, gathering technical information to provide feedback on designs from the first moment of development. On the other hand, it is necessary to raise awareness among developers of this technology so that they have a better understanding of the needs and values that should be present in the design of their vehicles, always keeping in mind the community of people with disabilities.

Conclusions: the social impact of a truly equitable transportation policy

The benefits of mass adoption of autonomous vehicles will transform the lives of people with disabilities, including older people with driving difficulties. The potential for new equitable mobility is undoubtedly unprecedented, as the ability to use the road network to get around without relying on others is transformed into a new sense of independence and freedom. Moreover, driving will become a much less dangerous activity, eliminating the factor that contributes most to traffic accidents: human error. As we have indicated, for the introduction of these vehicles to be orderly and successful, there must be a general consensus of confidence that the benefits far outweigh the disadvantages. As with any technology, the concept of risk is always subjective beyond any objective factor and depends on the social perception of risk. The ethical vectors that guide this development must be consistent with societal values. Fortunately, current social perception is moving towards a full recognition of the importance of the rights of people with disabilities, and equitable personal mobility is undoubtedly a human right that takes on a very special value for this group. It should be remembered that lack of mobility is a cause of isolation and isolation is a cause of mental health problems. Loneliness particularly affects the elderly and

people with disabilities. In urban areas, and especially in European cities, the problem of equitable mobility can be addressed through the engineering of public transport systems. However, in rural areas and in countries where the urban configuration is less concentrated and centralized, the means of equitable transport become a social necessity if we want to dignify the life and improve the health of these groups.

At a time when the Internet and social networks are turning us into people who increasingly live the world from home, glued to a screen, physical mobility is increasingly becoming a human right that needs to be protected by states. It is the responsibility of the public to create the necessary infrastructures so that transport does not discriminate against people with disabilities, and also to promote universal design, which allows the development of technologies that give these people the greatest possible independence to exercise this right to mobility, without any discrimination against the group of people who do not have special needs. Equitable transport means a mobility system available to citizens that does not discriminate on the basis of functional diversity or special needs, and by definition offers a range of equal transport options, not just patches or ad hoc solutions that only partially solve the problems. This is why it is necessary to adopt an equitable transport and inclusive mobility policy, within the parameters of universal design, which affects all modes of transport, as well as urban and interurban infrastructures, in order to achieve a mobility ecosystem characterized by social cohesion. Until last January, the Spanish Constitution referred to people with physical, sensory and mental disabilities instead of people with disabilities, which shows that the collective imagination still has the image that the problem is with the person and not with the technology. The degrees of functional diversity are infinite, and there are many circumstances in which any person may need special assistance to exercise their right to mobility. Therefore, it is time to

emphasize the need to adapt technologies to human needs. The problem does not lie in the shortcomings of nature, but in the ineffectiveness of technological solutions.

We need to go beyond the analysis of autonomous vehicles and their impact on people with disabilities and enter into the discussion of the characteristics that a truly equitable transportation system should have, one that promotes social inclusion at all levels, including the elderly who have a diminished capacity for autonomous mobility. In short, the promotion of autonomous vehicles may represent one of the greatest opportunities for people with disabilities to achieve levels of accessibility, freedom, and autonomy that would have been unthinkable just a few years ago. In a society where the Internet is so important in our leisure and work lives, where young people learn to relate to each other through their cell phones and find it increasingly difficult to relate face-to-face in real life, in a society that turns us into domestic cosmopolitans who can experience the world through travel documentaries without getting up from the couch, or access a huge catalog of movies without going to the cinema, or see and talk to our family or friends via video conferencing, we run the risk of becoming an increasingly humanized society. In this hyper-technological society, loneliness and isolation may be the price we pay for so much virtual communication. In this scenario where technology seems to be pushing us further and further away from each other, it is revolutionary to think that a technological development could bring people closer together instead of pushing them apart. An accessible and equitable transportation system, an ecosystem that favors personal mobility, can be an antidote to this loneliness and isolation, allowing many people who would not be able to leave home without help to do so at will, deciding for themselves when and where to go.

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