D6.2 Report on long term socioeconomic impacts of AV

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1. Introduction and Rationale

Autonomous Vehicles (AV), or self-driving vehicles, promise widely available, safe, clean, door-to-door transport for people and goods. Widespread use on Europe's roads is anticipated to happen in the next few decades and is expected to have numerous societal implications for equity, health, economy, and governance resulting in potential impacts on city development, infrastructure and design (from street to district- and regional development). However, research and models show that introducing AV would not necessarily lead to an improved traffic situation in the city or to sustainable developments in mobility. As the POLIS discussion paper on AV (2018) pointed out, expectations are being created that self-driving cars will be there tomorrow, will always operate perfectly and will solve congestion and eliminate accidents. While automated cars may bring some benefits, there is also the possibility that their widespread introduction in urban areas could lead to increased congestion, negative environmental impacts (unless all AVs are electric and/or powered by renewables), increased energy consumption and negative health impacts, if walking and cycling are discouraged and if appropriate regulatory frameworks are missing.

Truthfully, the implications of new technical developments cannot be clearly and precisely predicted today, as many factors enter into consideration. In the future, mobility is expected to be safer, more comfortable, more accessible and, in certain aspects, more efficient. Cities face the challenge of integrating automation in their planning while taking advantage of the opportunities/benefits that autonomous vehicles offer and, at the same time, minimizing the risks and potential negative externalities associated with them. Their introduction therefore needs to be carefully managed in the context of sustainable urban mobility objectives. In other words, even if they prove to be technically and commercially viable, it might be necessary to limit the use of AVs for policy reasons.

Understanding AV's (potential) impact on urban and rural development is just starting to grow and it is mostly academic and fragmented. Local and regional authorities' current knowledge is not sufficient to anticipate, and fully benefit from the arrival of AV. One of the challenges is to link technical, socio-economic and spatial aspects, across geographic scales (street, district, city and region) and time (short, medium and long term), and from academic, industry and practitioners. This paper contributes to overcoming this challenge as other EU funded projects have done before, projects such as CO-EXIST with their 'Automation Readiness Framework' or LEVITATE with the 'Taxonomy of potential impacts'.

Against this backdrop, the Interreg funded project PAV aims to develop green transport and spatial planning strategies that incorporate autonomous vehicles. To develop such strategies, local and regional authorities need to gain a deeper understanding of the potential paths of development, potential impacts, and chains of causality. Within the project timeline, the project PAV will produce two reports that will help to gain such a deeper understanding .[1] By linking the insights of these reports with the identified local challenges, opportunities and priorities of the local, regional and transport authorities, PAV partners will be able to develop strategies to steer the future arrival of AV efficiently and in line with local policy goals. This report examines various potential socioeconomic impacts surrounding the deployment of automated and autonomous vehicles in road transport, as well as factors that will influence such impacts. Overall, the aims of this paper are:

- to raise awareness among city and regional administrations, about the potential socioeconomic impacts of AVs and to assist them in setting transport policies and plans to deal with them;
- to raise awareness among the AV community about the factors that will determine the impact of AV;
- to challenge the AV community to develop products and services that fit the communities they will be used in and contribute to achieving sustainable mobility policy goals;
- to provide input for the development of spatial planning strategies by PAV partners.

This work is also intended as a think piece regarding the social reality accompanying the deployment of automated vehicles, discussions are necessary in order to set the course for the future of sustainable mobility.

2. Methodology

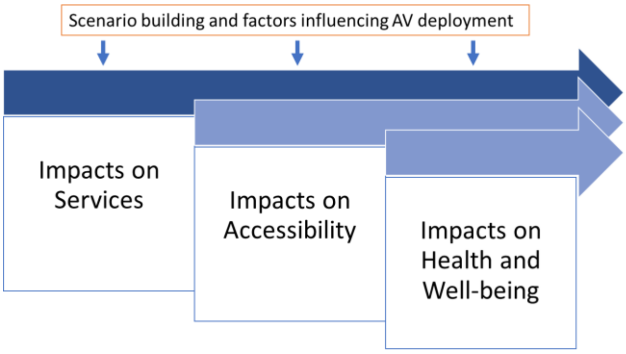
This study was done by POLIS within the PAV project. The report used a qualitative methodology based on an extensive literature research, interviews with selected stakeholders and a validation workshop.

In order to get a better insight of the topic, interviews were carried out with partners from other AV focused EU funded projects as well as other experts in the field. The interviews were carried out by phone and lasted between 30-90 minutes, depending on the number of interlocutors present at the interview. The interviews did not followed a common structure as they were tailored to the speaker in order to get a more in-depth understanding of the studied topics.

The literature research reviewed results from different AV focused EU funded projects (i.e. LEVITATE, CoExist and AVENUE) and, given the long-term perspective of the report, was largely based on academic literature found in the main scientific databases.

The report is divided in 4 sections: Scenario analysis and influencing factors, impacts on services, impacts on accessibility and impacts on health and well-being. As many of the sections are connected and related to each other, an order was established to facilitate the reading of the report, with each section referencing or relating to the previous one.

[1] Second report to be published at the end of 2021.



3. Scenario analysis and influencing factors

Autonomous Vehicles are continuously being marketed as the ultimate transport revolution. However, the reality is very different as it is not known what the impacts of AV will be and how the built environment will affect their future. Although it is very complicated to predict the future, forecasts continue to be produced, as major transport planning decisions need to be justified and cannot be based on faith alone. Repeatedly, recent forecasts are treated as accurate statements, and strategies are set accordingly even though the tendency to get demand forecasts wrong is well established.[2] Reliance on singular forecasts must be avoided and cities should rather embrace uncertainty by developing multiple scenarios for the future. By considering multiple possible futures, potential strategy weaknesses can be identified, and adjustments can be made to ensure their performance in a variety of situations.

A scenario is a picture of one possible future. It consists of a combination of elements that lie largely outside of the city's control (e.g. the nature of technology, society's rules, trends like climate change or ageism) but that will greatly affect the functioning of the city and the capacity of the city to deal with them. In order to derive some benefit from scenario-based planning, several scenarios need to be studied and they must be quite different.[3] This will enable authorities to effectively plan for a range of changes and uncertainties through decision making processes that not only consider what is likely to happen but what the city would like to see happening in the future.

In order to set the scenarios, cities need to study the influential factors that will significantly determine the future of mobility and, in this case, the level of usage and deployment of autonomous vehicles. Once identified, cities can influence and organize some of these factors in order to advance towards their vision, the future of the city as they would like it to be.

[2] Flyvbjerg et al., 2005.
[3] Cohen, 2018.

FACTORS THAT WILL INFLUENCE THE DEPLOYMENT AND USAGE OF AUTONOMOUS VEHICLES

-Regulation

-Politics and political environment

-Technology development, availability and infallibility

-Liability and insurance

-Human behaviour towards mobility

-Societal factors

-Cybersecurity

-System reliability

-Infrastructure

-Transportation Options

-Maturity of telecommunications

-Traffic rules

-Acceptance of autonomous systems

-Social implications, e.g. on workforce

-Cost

These factors interact with each other and are presented in the different analysed impacts throughout this report.

4. Impact on Services

4.1 Shared Mobility

The actions of autonomous vehicle manufacturers and related industrial partners, as well as the interest from policy makers and researchers, point towards the likely initial deployment of autonomous vehicles as shared autonomous mobility services (similar to today's car-sharing services).

Shared Autonomous Vehicles (SAV) will most likely have lower fares by eliminating the driver cost, increasing the affordability of the system. Additionally, these services could be made available 24h a day, enabling provision of services during extended operating hours.

SAVs present a potential opportunity to serve demand efficiently in suburban and rural areas, wherever demand is not high enough to implement regular fixed Public Transport Systems.[4] From a policy perspective, the deployment of SAV can contribute to the sustainability and efficiency of the transportation system by introducing them to cover first and last mile services.[5] However, if introduced as an unregulated independent system of if the public transport system they feed does not cater to the needs of the users, SAVs would induce an undesired modal shift from public transport and active modes, leading to increased congestion in urban areas.

In their study of accessibilities, Meyer et al. (2017) concluded that a total substitution of public transport systems by a SAV system would lead to increased congestion, even in rural areas where major connectivity nodes would be affected. Wherever demand is high enough, public transport remains the most suitable option. To exploit SAV benefits, policy makers need to integrate SAVs with an efficient public transport system and impact studies need to shift their focus and evaluate their deployment in an integrated manner rather than as independent systems.

If the market of SAV is non-integrated and privately dominated, SAVs will most likely be underserving suburban/rural areas (where the mobility/accessibility benefits would be higher) and overserving urban areas,[6] given that it is likely that private providers would operate according to the market and not to solve other problems or serve policy goals. In such a scenario, it also would not be hard to imagine a market situation where private providers establish different premium tariffs leading to an increase in inequality. SAV technology could end up reproducing social, ethnic and gender biases already evidenced within ride-hailing technologies, further increasing inequality.[7]

We also must not forget the social reality of using shared mobility. Rural areas are usually close-knit communities where individuals may be less prone to share rides with strangers in unsupervised vehicles. Studies imply that tech-savvy males, younger people and more educated would be the early adopters of these services.[8] Other members of society may have to get used to these systems, especially in rural and suburban areas, and cities/regions could encourage their use with subsidies or with marketing and communication campaigns, provided they indeed deliver a positive contribution to the sustainable mobility ecosystem they envisage.

As stated above, the introduction of SAV will raise potential concerns linked to congestion and equity, and policy makers need to be aware of this and plan ahead. The benefits from SAV are also dependent on critical mass and the majority of studies seem to point out that SAV will cover less than 50% of the current trips performed.

[4] Berharnt et al., 2018.

[5] Bösch et al., 2018; Cyganski et al., 2018; Pakusch et al., 2018; Soteropoulos et al., 2018.

[6] Loeb et al., 2018; Lokhandwala and Cai, 2018; Zhang and Guhathakurta, 2018.

[7] Cohen and Hopkings, 2019.

[8] Bansal et al., 2016.

4.2 Public Road Transport

Similar to the SAV system, autonomous buses could be an effective solution for areas with low demand, where fixed and frequent lines are not cost-efficient for the operators, such as certain suburban areas, tourist destinations or rural areas. Especially in rural areas, where the cost of the driver amounts to almost 50% of the total costs, operators could use the technology to offer an increased service coverage and frequencies, that is, once the technology is mainstreamed and therefore economically viable.[9] Experts seem to agree that where demand is sufficient, like in urban areas or on major routes, mass public transit will remain the appropriate and most effective solution given that such an investment in technology and infrastructure would not be justified without the added accessibility benefits. Although there is also potential in the automation of mass public transit services like trains and metros, it escapes the scope of this study as it focuses on autonomous road transport.

The practicalities of implementing self-driving buses should not be overlooked. By eliminating the driver, operators would also be eliminating the help that some users may require to access the vehicles (e.g. elderly and disabled) or to ask for directions. Manufacturers and operators need to offer practical solutions to these issues. Ticketing could potentially be an issue, operators need to offer solutions that are easily accessible and affordable, in this sense AV could be a driver for ticketing integration.

Besides technology availability, liability remains an important barrier for AV adoption. As ITF points out in their 2015 report 'Automated and autonomous buses: regulation under uncertainty', expanding public insurance and facilitating greater private insurance could provide sufficient compensation to those injured by an automated vehicle while relieving some of the pressure on the tort system to provide such a remedy. In the future, as automation increases, liability could gradually shift from drivers to manufacturers.

4.3 Tourism

Most of the literature done on CAV in cities is concerned with commuting and other daily mobility patterns, yet depending on the degree of deployment, tourism could also be affected by the potential transition. This ranges from airport shuttles, through city taxis, to car rental and vehicle-based guided sightseeing. By eliminating the driver, the costs of such vehicles could become significantly lower, but it is not clear how losing the interaction between 'local' drivers and tourists would actually affect the quality of the experience. These encounters may instead be replaced with advertising, which would benefit large multinationals rather than local businesses and could have significant impact on the local economy.[10]

Nevertheless, CAVs could help to overcome international tourists' barriers to renting a car in a foreign environment. The risk of jet lag, fatigue, misunderstanding of new driving rules, and cultures of mobility could be minimized. New tourist destinations may emerge with CAV deployment and rise in popularity, existing attractions that were hard to reach or new secondary cities could benefit from newly found transport connectivity. However, this could

[9] Berharnt et al., 2018.
[10] Cohen and Hopkins, 2019.

also negatively impact cities' efforts to encourage sustainable urban tourism, resulting in crowds of small AVs congesting urban tourism spaces. It is possible that tour buses become obsolete with the deployment of CAVs and, should this happen, major tourist attractions can anticipate a significant increase in congestion, especially if those attractions are located in urban areas.[11]

4.4 Freight Services

Urban and rural deliveries could be transformed by automated deliveries, reducing delivery costs by 80% to 90% compared to a human doing it, depending on the vehicle and the platform.[12] Studies and test pilots point at autonomous vehicles with incorporated lockers as the vehicles that will revolutionise last-mile delivery, with faster and more reliable deliveries. The benefits will depend on public regulations, labour costs and settlement structures and they will not be as high in rural areas as in urban areas. However, it is unlikely that logistic companies would significantly invest in AV before they can drive fully automated (SAE level 5), even if the individual inside the vehicle can compensate by doing more administrative tasks. The impacts that delivery AVs would have on urban mobility flows are still uncertain and they will be determined by the spatial distribution of pick-up and drop-off areas, size of the vehicles and in place policies (e.g. delivery time windows for freight).[13] Ranieri et al. (2018) concludes that the positive effects of delivery AVs on negative externalities would be higher by combining different solutions (e.g. bike courier or drones) to create a "smart logistics system".

Vehicle platoons are a particularly promising application for long distance freight transport. Benefits could include significant fuel savings and, for the fleet operators, potentially lower labor cost.[14] Next section further elaborates on employment impact in freight transport.

5. Impacts on Accessibility

5.1 Employment

Studies show that the impact of CAV on employment varies widely by the scale and scope of technology adoption. It can be expected that high implementation of AV in services will see significant declines in driver employment, while other jobs may not be as directly impacted and new jobs may arise[15].

Some of these AV applications may need specialised infrastructure, both physical and digital. A high deployment of AV could lead to an increase in infrastructure maintenance jobs, from painting street lines to removing physical obstacles. Digital infrastructure might include the maintenance of highly detailed roadway maps and pertinent traffic operations data, which would lead to a growth in IT related jobs and jobs in control centres.

[11] Cohen and Hopkins, 2019.
[12] https://pathtopurchaseiq.com/autonomous-delivery-vehicles
[13] Kassai et al., 2020.
[14] ITF, 2015.
[15] Executive summary Study exploring the possible employment implications of CAV

It is believed that fully automated trucks and buses could change the job profile asked for the in-vehicle individual, combining supervising with more administrative tasks in the former and turning into a trip attendant for the latter.[16] It is not clear when freight AV transport will be able to operate without a human in the vehicle, if ever, and it is difficult to see how the savings in terms of streamlined administrative tasks can compensate for the higher investment cost in the vehicle, considering that the 'driver' cost would still be a part of the equation. It is also difficult to imagine how a person that needs to supervise truck driving (therefore, needing driver and maneuvering skills to some degree) could carry out administrative tasks simultaneously. Similarly, having a trip attendant in passenger transport seems to invalidate the rationale behind operators investing in CAV, even though it could undoubtedly improve the travel experience. Although some industries will experience a positive impact, Täihagh and Lim (2019) argue that growth of autonomous vehicles will increase economic inequality, because of employment redistribution of low–skilled workers, e.g. vehicle drivers.

In a scenario where CAVs are used to improve urban/rural transportation systems with SAVs and on-demand services, there is a potential increase of accessibility which would mean higher opportunities of employment and academic formation. However, the contrary would happen in a scenario where deployment of CAV turned into an increase of congestion, hence less opportunities can be reached or it's harder to reach them.

5.2 Land Use

4.2.1 Parking

Under a high SAV-use scenario, there is high potential to increase the livability of cities by reducing urban land used for parking – assuming the space is used for civic rather than economic purposes.[17] Such a transformation linked with supportive political, social and cultural contexts could bring exceptional socio-cultural benefits and improve the quality of life in cities. With a reduction of parking demand, cities could repurpose on-street spaces for other uses such as implementing new infrastructure for cycling and walking, additional segregated public transport lanes, facilitating micromobility with additional non-auto parking spaces or enhancing public outdoor space with more green, parklets, etc.[18]

In a scenario dominated by SAV, it could be assumed that cruising without a driver becomes more convenient than paying the expensive parking fees that dominate the city centres. Thus, it can be expected that the demand for parking lots shifts to sparsely populated areas, where parking space is not a scarce good.[19] The majority of studies that focus on parking–related aspects of land use foresee a substantial reduction in parking space requirements, some concluding a reduction of as high as 90 %.[20] However, most of the research does not take into account the necessity to implement pick-up and drop-off points that SAV and delivery services would require, therefore the liberation of space concluded should be interpreted as too

[16] Executive summary Study exploring the possible employment implications of CAV
[17] Cavoli et al., 2017; Cohen and Hopkins, 2018.
[18] Clark and Brown, 2020; Cohen and Hopkins, 2019.
[19] Chapin et al., 2016; Zakharenko, 2016
[20] Zhang et al, 2015.

optimistic. Removing on-street parking and relocating parking to the outskirts of the cities could have a significant negative influence on the traffic flow and, consequently, the externalities of transport such us emissions and accidents could increase significantly. There is also the concern that the AV behaviour in these loading zones and the free flow intersections will hinder pedestrian and bicycle travel.[21] Dynamic curbside management allocates curbside space as a resource in response to real-time demand to optimise operations and it could be an important element to achieve an efficient SAV network.[22] Local authorities will have to design such spaces to optimise flows, and their requirements must be included and analysed in scenario planning to accurately evaluate CAV impact on parking.

A particular challenge derived from parking space reduction is the potential upset of municipal budgets. Cities should analyse the issue with scenario planning to fully comprehend the revenue implications and identify alternative solutions. However, the reduction of parking spaces in city centres is already a trend that has been initiated to further discourage private car usage in city centres. Loading zones could be an alternative funding source while simultaneously addressing congestion issues. Studies also suggest that cities should focus policy effort in commercial and mixed-use areas since they are projected to have larger revenue shortfalls.[23]

4.2.2 Residential location

Economic literature suggests that, when selecting housing and working locations, households make a trade-off between factors such as income, commute-time, living costs, etc.[24] Considering house-prices and rent are lower with increasing distance from city centres, it is easier to access superior housing outside cities or in their suburbs, but it comes at the expense of lower wages in rural areas or longer commuting time. The deployment of AV may affect this trade-off, with longer commutes becoming less inconvenient in autonomous vehicles, relieving the driver from the driving task and enabling them to engage in other activities like work or entertainment.[25] However, some literature has positioned the possibility of multitasking in an automated vehicles as a relative low benefit of the technology, contrasting with being able to enjoy the landscape or talk with other passengers as higher ranked benefits.[26]Willingness to drive longer distances could also have an impact on the choice of destinations and ultimately on residence location. Hence, deployment of AV (both in a privately dominated and a shared dominated scenario) could lead to an intensified suburbanisation and changes in the settlement structure, which could also lead to an increased motorisation and a higher demand for transport infrastructure and management.[27]

However, there is no consensus on the matter. Zhang and Guhathakurta (2018) conducted an analysis at detailed level including a residence location choice model and concluded that

[21] Chapin et al., 2016.
[22] Roe and Toocheck, 2017.
[23] Clark and Brown, 2020.
[24] So et al., 2001; Bhat and Guo, 2007.
[25] Silberg et al., 2012; Heinrichs, 2016; Cyganski et al., 2015.
[26] Park et al., 2019; Cyganski et al., 2015.
[27] Fraedrich et al., 2018; Gelauff et al.,2017; Soteropoulos et al., 2018; Childress et al., 2015; Milakis et al., 2017.

the introduction of SAV will not result in uncontrolled sprawl. Additionally, Wagner et al. (2014) raised doubts about claims that vehicle automation technologies would affect commuting patterns and suggests that other technological developments outside of vehicle automation, like maturing telecommuting technologies, could have a greater impact on travel and urban development patterns. With matured telecommunication technologies or if home-based teleworking is enhanced, other decision factors like personal well-being, health, general livability, may have a higher weight in the trade-off, leading to an increase in rural and suburban developments.

5.3 Access to individual travel

Rural populations are often isolated as a result of cuts in public transport, or existing difficulties to access the few services that still exist. The solutions put in place by local authorities or private players often tend to be inefficient, mainly due to driver cost constraints. Demand Responsive Transport solutions or car-pooling schemes have helped in occasion to improve the situation, but in many cases ended up failing due to a lack of visibility or attractiveness, or failing business models. Public transport systems based on autonomous vehicles, with higher door-to-door mobility and flexibility, could lead to a significant increase in accessibility of rural areas. It is also believed that increasing accessibility in rural areas would have a knock-on effect on the economy.[28]

Affordable, competitive trips provided by a personal or shared AV could improve the opportunities a nondriver could access in urban areas as well, but its effect could be even higher in more suburban, automobile-oriented contexts. Nonetheless, a high deployment of private automated vehicles or an unregulated scenario with SAV dominance would eventually lead to an increase in congestion in urban areas and high connectivity nodes, therefore decreasing accessibility of the system.[29]

Once autonomous vehicles have reached their full potential, they could benefit in particular three user groups. First, the elderly who are not able to drive and cannot access traditional public transport. Second, people who do not own a driver license, including people who are not yet of driving age. And the third group is people with disabilities, who have difficulty accessing traditional transport systems, especially those with cognitive difficulties. However, autonomous vehicles will decrease physical accessibility for people that might need assistance with boarding a vehicle and AV developers should be incentivized to provide an accessibility solution for a variety of social groups, including those with physical disabilities. Recognizing how different groups are affected by AV developments is important to understanding regional mobility and accessibility to jobs and resources.[30]

[28] Von Mörner, 2019.
[29] Meyer et al., 2017; Childress et al., 2015.
[30] Berharnt et al., 2018.

6. Impacts on Health and Well-being

6.1 Public health

6.1.1 Emotional well-being

Increasing accessibility in rural areas would result in a massive increase in individuals' quality of life, with knock-on benefits for their psychological and physical wellbeing. That is when autonomous vehicles ensure safe, convenient and affordable trips. The potential increase in congestion in urban areas due to induced demand of AV could have the contrary effect and decrease livability, with knock-on negative impacts for individuals psychological and physical wellbeing.[31]

In the behavioural context, it is unknown what the human reaction will be when depriving them of the possibility of autonomous decision, regarding style and manner of driving, as well as use of road infrastructure. There is a need for an in-depth analysis of the mechanisms of behavioural compensation by the driver of this state of affairs, especially considering there is a concern that relieving the driver of decision-making capabilities while participating in road traffic can negatively affect their psyche inducing extreme behaviour, which could result in potentially dangerous situations.[32]

6.1.2 Air quality

AV pilots and studies indicate that the deployment of CAV will lead to an increase in VMT/VKT while emissions will significantly be reduced, majorly depending on application of efficient electric vehicles.[33] However, research also shows that this reduction will also depend on SAV adoption and the optimisation of charging methods and infrastructure.[34] Overall, it is believed that AV could contribute to improving air quality in the short term while impacts are uncertain in the long term. Nevertheless, it remains a necessity to shift the source of power generation from fossil fuels to renewable energies.[35]

6.2 Road Safety

In the European Union, road accidents are the first cause of external reasons of death for people up to 45 years of age, generating a yearly loss of over 200 million EUR. Fully autonomous driving means transferring the driving task to a computer system and thus eliminating the human factor which is at the root of many road accidents.[36] Several studies corroborate that autonomous vehicles would lead to an increase in road safety with different degrees of impact. Although accidents can be reduced to a greater extent, research also shows

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31 Berharnt et al., 2018.
32 Michałowska and Ogłoziński, 2017; European Transport Safety Council (ETSC), 1999.
33 Arbib and Seba, 2017; Bauer et al., 2018; Fagnant and Kockelman, 2014; Fournier et al., 2017; Fulton et al., 2017; Greenblatt and Saxena, 2015; Lokhandwala and Cai, 2018; Martinez and Viegas, 2017; Salazar et al., 2018; Vleugel and Bal, 2018,
34 Lokhandwala and Cai, 2018; Salazar et al., 2018 ; Jones and Leibowiz, 2019.
35 Milakis et al., 2017
36 Michałowska and Ogłoziński, 2017

that will not be possible to eliminate them completely as machine errors will exist, leading to the need of new liability legislative frameworks.[37]

In order to develop a sufficiently clear picture of the driving environment on which to make correct and safe decisions, autonomous vehicles mobilise a number of sensing devices. As vehicles move up to higher levels of automation on the SAE scale, the relative importance of these sensing inputs increases as the potential for human drivers to make corrective action (using their own sensing and cognitive capabilities) diminishes and, ultimately, disappears.[38] In a study in 2017, the University of Michigan found mixed results regarding the ability for hardware/software systems to replicate and improve on human sensing capabilities. They found out that, even in the case of multiple sensor fusion, human capabilities still outperform that of automated systems in certain problematic and complex contexts. Some common traffic scenarios still confuse automated driving system capabilities, and the safety of pedestrians, cyclists and other vulnerable road users is a serious threat accompanying autonomous vehicles in road traffic.[39] Given that not all accidents can be avoided, these complex situations will cause accidents where AVs will be required to make difficult ethical decisions in cases that involve unavoidable harm. Thus, it is necessary that these types of decisions are taken well before AVs become a global commodity.[40]

It is quite uncertain if autonomous vehicles will become the norm in the future and, before that happens, it can be safely assumed that mixed traffic (different SAE levels) will be the reality for at very least the next couple of decades. Such a situation can result in only limited improvements in traffic safety.[41] In fact, ITF highlights in their 'Safer Roads with Automated Vehicles?' report (2018) that several players in the automated driving field share the believe that hybrid interaction between AV and humans (SAE level 3-4) is inherently unsafe and are designing systems that completely jump over intermediate levels of automation.

6.3 Security

Autonomous vehicles are also associated with both physical and cybersecurity concerns. SAVs and Public Automated Transport will likely be monitored to prevent violence to vehicles and inside vehicles, but such surveillance may be rapidly overcome, disabled or removed. Moreover, personal CAVs will likely be immune from such surveillance.[42] Such violence may become a decisive factor for operators to determine operational areas, with certain areas (predominantly suburban and peripheral areas) being targeted due to their high-crime rates, invalidating potential positive accessibility impacts.

Personal safety concerns shape women's transport behaviour across all transport modes more than men and it is the top priority for women as a condition for using public transport.

[37] Teoh and Kidd, 2017; Täihagh and Lim, 2019; Hayes, 2011.
[38] ITF, 2018a.
[39] Shoettle, 2017
[40] Bonnefon et al., 2016
[41] Naranayan et al., 2020
[42] Cohen and Hopkins, 2019

In a scenario with dominating public automated transport systems, women may also have legitimate safety concerns regarding accessibility to stops and vehicles (i.e. lighting, visibility, physical access for strollers), verbal and physical harassment and violence, that could significantly limit their mobility.[43] Policy makers and operators need to address these concerns, include them in their strategic planning and find solutions, benefiting not only women but all transport users.

Different studies explore cybersecurity issues related to autonomous vehicles concluding that data storage and transmission capacities of AV could result in privacy risks and opening networks of AV to malicious attacks.[44] The International Transport Forum (2018) discusses these issues and gives recommendation to lessen the impacts. Recommendations such us the establishment of comprehensive cybersecurity for automated driving and functional isolation of safety-critical systems.

7. Conclusions

As highlighted in this report, the long term impacts of autonomous vehicles are still uncertain and emergence of the technology needs to be taken into account by public authorities to prevent negative impacts. In the future, mobility is expected to be safer, more accessible and more efficient, but the implications of autonomous vehicles cannot be predicted. Current AV pilots help to understand some of the impacts AV will have in the short term, but their long term vision is limited as some of the impacts will not appear until there is a high level of penetration and deployment of the technology. Additionally, many of the benefits associated with CAV are dependent on a number of factors such as acceptance of the technology, integration with existing services or external societal factors.

By analysing different scenarios, cities can identify influenceable factors and can be prepared to deal with a range of changes and uncertainties through decision-making processes. This report studies several impacts that could arise from the deployment of autonomous vehicles and points out the different factors or circumstances that will determine them in order to help local and regional authorities to plan for the arrival of the technology and integrate it in their long term strategies.

Finally, this study highlights that any action with respect to the deployment of AV needs to go beyond solving localized problems and should respond to more fundamental challenges and goals cities face, such as tackling the climate emergency or improving accessibility and equity.

A second paper will be produced analysing possible policy options to deal with the integration of autonomous vehicles in spatial and mobility strategies.

[43] ITF, 2018b.

[44] Täihagh and Lim, 2019; Petit and Shladover, 2014.

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