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Can Autonomous Driving Contribute to Sustainable Urban Mobility?

S.Grigoriadis[1], K. Karagiannis[2], N. Grigoriadis[3]

1. *National Technical University of Athens, School of Architecture, Urban Planning Research Lab, Athens, Greece, sofgrh@gmail.com*
2. *University of Thessaly, School of Engineering, Department of Civil Engineering Volos, Greece, karagiannisofficial@gmail.com*
3. *University of West Attica, School of Applied Arts & Culture, Department of Interior Architecture, Athens, Greece, gregoriadis.n@gmail.com*

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Abstract: Autonomous driving is that innovation - the result of the application of Artificial Intelligence in the automotive sector - which represents the future of transport and whose applications will have an impact not only on the motorist sphere but also on many aspects of the society in which we live. The common idea is that self-driving cars are a recent invention, a frieze of the 21st century, however the reality is different.

The historical analysis of the automotive sector and Artificial Intelligence applied to the automotive world will allow us to deepen what has been achieved so far and what still needs to be done. It will then be interesting to understand the possible impact that the autonomous revolution will have on society and people's lifestyle. Self-driving vehicles today are not perfect yet, so we will try to identify and analyze the technical and non-technical problems that contribute to slowing the entry of self-driving vehicles on the market.

Keywords: *autonomous vehicle; connected and automated driving; sustainable urban mobility; urban planning;*

1. Introduction

Self-driving cars have their roots even in the decade of twenties of the last century when the American radio equipment company Houdina Radio Control created Linrrican Wonder, a radio-controlled vehicle capable of making a demonstration tour in New York, between Brodway and Fifth Avenue. Since that day, there have been many steps forward and today autonomous driving can be considered a reality.

In the future, situations will arise that will require rethinking policies and strategic choices both on the part of the various players operating in the sector and on the part of city administrations. The latter will have to rely on autonomous solutions to counter the increase in traffic and road accidents. Some studies also predict an exponential growth in the number of people who will decide to move to large urban centers. An increase in population density will cause an overload of the current public transport infrastructures which, if not supported by large investments, will risk not being able to meet the needs of all citizens.

In the last decade, the technology related to autonomous driving and artificial intelligence has developed to such an extent that the first driverless vehicles have been tested on the roads. Many are the benefits expected from the transition from manual vehicles to Self-driving Vehicles (SDVs), including in particular greater road safety for both drivers and weak road users, a reduction in congestion, greater accessibility. and a lower environmental impact.

Despite the high expectations that SDVs are generating in car manufacturers and public administrations, the technology has not prove yet it works as promised, and the benefits all remain to be verified. Indeed, a certain caution is spreading over the first revolutionary announcements, and many researchers are focusing their attention on the possible negative externalities that SDVs could generate.

The goal is to present the measures that the Public Administration (PA) should implement in the short, medium and long term, to guide the transition of autonomous driving towards a future scenario based on the sustainability and livability of the urban environment. The research deals with the issue of SDVs from different perspectives, starting from how they can modify the daily practices of citizens, the demand for mobility, the location choices, and the consequent effects on the settlement structure and on the configuration of public space in big Cities.

Furthermore, it evaluates how the dissemination of SDVs can be managed in an integrated and sustainable way, with particular reference to policies and strategies relating to transport and land use.

2. The Mobility of the Future – Literature Review

What are self-driving vehicles (SDVs)

Autonomous driving is considered as one of the key innovations of these first decades of the 21st century, capable of revolutionizing the urban and extra-urban mobility system, and transforming people's daily lifestyle. Thanks to the introduction of Artificial Intelligence in driving systems, vehicles are becoming increasingly 'intelligent', able to park themselves, change speed or direction of travel.

SAE International (Society of Automotive Engineers), an American body that develops and defines engineering standards in the aerospace, automotive and vehicle industries, has defined the SDV, or Automated Driving System (ADS), as "The set of hardware and software capable of performing the entire DDT (dynamic driving task), regardless of whether it is limited to a specific ODD (operational design domain); the abbreviation ADS is used to specifically describe a level 3, 4, or 5 driving automation system "(SAE International, 2018) . This technological evolution is relieving the driver more and more from normal driving operations, passing on an increasing number of responsibilities to the vehicle. The automation of the driving system varies according to technical developments; has been classified by SAE International on 6 different levels, taking into account the role of the driver and the context in which the vehicle moves, Figure 1.

If the technological development of SDVs has already been outlined, the timing with which these levels of autonomy will be reached, is much more uncertain. Until today only a few cars in the market reach level 2, and there are still no reliable predictions regarding the marketing of autonomous vehicles of level 3, 4 or 5 (Litman, 2019). In fact, the high technological uncertainty does not allow us to define a safe time horizon, but it does not seem to question that sooner or later we will see driverless cars. Among the most optimistic, are the car manufacturers that have repeatedly announced the entry into the market of SDVs by 2022, subsequently having to contradict themselves to postpone the date of actual marketing (Bazilinskyy et al., 2019).

In the decade that is about to end, we have probably reached the apex of expectations about the speed of the transition to SDV (Johnson, 2017). These expectations were partially disillusioned by the first accidents involving vehicles with assisted driving; conducted in an approximate and careless manner by real people, also due to marketing strategies and information levels that are too superficial with respect to the actual technological advancement of these media.

What makes predictions about the diffusion of SDVs in an urban environment difficult, is precisely the complexity of the city, and the fact that vehicles will not have to move in a closed and controlled environment but will be subject to multiple factors of interference. According to Milakis et al (2017), market penetration rates may vary between 1% and 11% (semi-autonomous SDV) in 2030 and between 7% and 61% (fully autonomous SDV) in 2050. Other studies predict different penetration rates, for example Begg (2014) reports to 2030 a presence of vehicles equal to 80% for level 2, 39% for level 3 and 10% for level 4. According to Underwood (2014), however, in 2030 we will again see the introduction of the first level 5 SDVs. Analyzing public expectations, (Bazilinskyy et al., 2019) these further anticipate the times, suggesting that by 2030 the level 5 SDVs will be too widespread.

However, all these forecasts could be excessively optimistic, not only for the very uncertain aspects of the development of the technology, but because generally these studies do not take into account as a whole (and related interdependencies) a series of fundamental conditions for the diffusion of SDVs. For example, the renewal rate of the vehicle fleet, the time and financial resources for the adaptation of the road infrastructure, the problems of interaction between SDV and human-driven vehicles, the safety of weak users, the availability and location of parking lots, etc. (Johnson, 2017).

Furthermore, regardless of the exact year of release of SDVs on the market, the effects they will produce on traffic, safety, and the environment will not be immediate, but will only be realized when they have replaced the majority of the traditional vehicle fleet. On the contrary, the adaptation of the infrastructure and road space will have to anticipate the diffusion of SDVs, to allow their circulation. It is therefore essential to predict what effects the SDVs will produce on the road space, in order to implement actions and policies useful to reduce possible negative externalities on the demand for mobility and urban livability.

The potential spatial effects of SDVs

The spread of SDVs will probably have a disruptive effect not only on means of transport, but on the entire mobility system. From a structural point of view, SDVs will no longer be just means of movement, but could become real extensions of personal spaces such as the office or residence, for example the 360c concept proposed by Volvo. Or they could transform to carry both people and goods depending on the time of day and needs, as in the Urbanetic concept of Mercedes-Benz Vans. Litman (2019) identifies a series of benefits that could accelerate the uptake of SDVs in their diffusion; in particular the time gained for personal activities, such as resting or working, as it will no longer be necessary to drive to move or to find a parking space.

On the contrary, if the circulation of SDVs will be limited to certain environments or environmental conditions, it could generate situations of "accessibility anxiety" in users (Grush, 2016), due to not being able to reach any destination and delaying their spread as in the case of electric vehicles, which cause “distance anxiety” due to a charging network not yet widespread (Philipsen et al., 2019).

In addition, SDVs could increase the accessibility of categories of users who currently cannot drive such as disabled, elderly, and non-licensed people (Papa and Ferreira, 2018), but depending on the cost of purchasing this technology, and maintaining it, it could exclude many individuals from owning a private vehicle. At the same time, the lack of a driver and the reduction of service management costs (López-Lambas and Alonso, 2019) could incentivize new business models based on the sharing of autonomous vehicles, or the promotion of public transport.

According to Chicco et al. (2018), three - quarters of a statistical sample of 44 car sharing service operators from 20 different European cities consider "likely" or "very likely" that SDVs, once available on the market, will be used for such services. Greater road safety is certainly another of the expected benefits of SDVs, even if the technology is unlikely to completely eliminate the risk of an accident, since the additional risks that the same technologies can introduce are neglected (Litman, 2019). Finally, it is assumed that the diffusion of SDVs will take place through electric vehicles, eliminating the emissions of gaseous substances on site. However, it will be necessary to evaluate the possible externalities starting from the energy source used to produce electricity up to the disposal of the batteries.

These potential effects, which may seem positive in the short term, however, risk turning into negative externalities in the long run (Childress et al., 2015; Legacy et al., 2018; Milakis, 2018). In particular, traffic could increase as a result of the generation of new demand for mobility, for example by social groups that now have limited access to cars (disabled, elderly, and non-licensed people). Furthermore, the possibility of driving driverless vehicles to search for parking or to reach parking areas outside the city center could generate an empty vehicle traffic problem. Several authors predict an overall increase in the kilometers traveled, with increases that vary significantly due to factors such as the territorial context, the level of autonomy and the spread of sharing (Soteropoulos et al., 2019).

Another variable that will affect the spatial impacts of SDVs is the value that will be attributed to the time spent in the car. Since the driver will become a passenger himself, it is possible that the distance between the place of residence and that of work no longer represents a constraint in the choice of location, triggering new processes of settlement dispersion and sprawl (Meyer et al., 2017) . Dependence on cars could increase, further reducing the share of Local Public Transport (LPT), cycling, and pedestrian mobility, without considering the possible conflicts between SDVs and weak road users (Parkin et al., 2017).

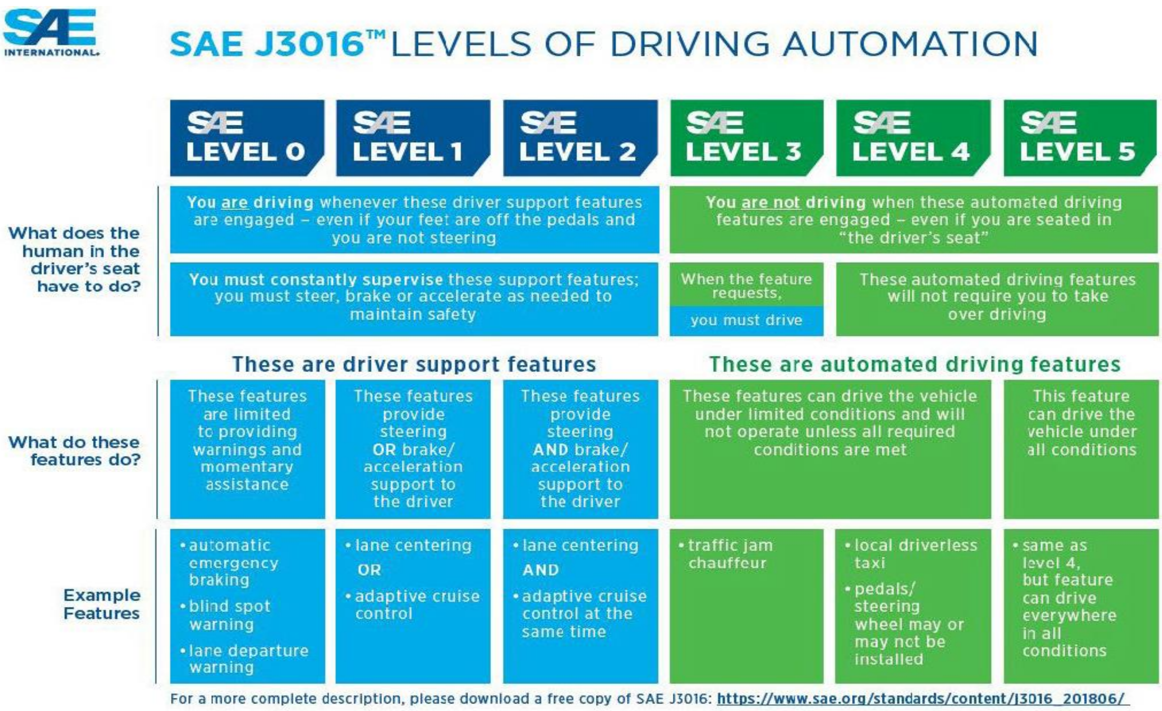

Figure 1: *SAE classification levels of driving automation. SAE International Releases Updated Visual Chart for Its "Levels of Driving Automation" Standard for Self-Driving Vehicles, SAE International, 2018*

3. Urban Sustainable Mobility Plan

Building a Mobility Management Plan, together with an on-site SDV experimentation, could facilitate the comparison between these who produce the mobility systems and those who have to regulate them. The bilateral effort, on the one hand, would allow the Public Administration (PA) to better understand the technology and prepare the right policies to regulate innovation, and on the other hand, it would allow the development of a shared vision between the public and private sectors.

In recent years, the issue of governing the impacts of SDVs has been the subject of growing interest on the part of the international scientific community, which warns of a widespread attitude of 'passive observation' by Public Administrations, hoping for more active involvement. However, despite the growing awareness of the importance of governing the diffusion of SDVs, there remains a difficulty in having to deal with an unpredictable future. According to a research by Fraedrich et al (2018), the greatest difficulties derive from the fact that those involved in transport planning are adopting a cautious and wait-and-see attitude due to strong doubts about the impact of SDVs and their timing of dissemination.

The SUMP represents a long-term strategic plan (with a ten-year horizon), which must be updated every five years, in line with spatial planning, according to the principles of environmental, social and economic sustainability. The main objectives must be "improving accessibility to urban and peri-urban areas, through sustainable and high-quality mobility and transport systems, including from an environmental, economic and social point of view, and improving the usability of public space.

The Decree of 4 August 2017 (g.u.n.233 of 5 October 2017) introduced the Italian guidelines for the SUMP, incorporating the principles of integration, participation, monitoring and evaluation that should characterize these tools according to European guidelines. The SUMP can be drawn up at an urban or large area level and integrates the other existing planning tools. Indicates the policies and measures concerning all modes and forms of transport, public and private, passengers and goods, motorized and non-motorized, circulation and parking. For this reason it represents the key tool with which local governments will have to guide the introduction of SDVs in the overall mobility system (Begg, 2014).

The ELTIS guidelines for SDVs

In the second edition of the ELTIS guidelines (2019), a section has been inserted, which explains to the Public Administrations the key role they will have in the transition phase, and suggests that they intervene immediately to prepare the city for the mobility of the future.

The mode of transport changes but not the goal: for the European Commission, the "vision to be achieved must remain that of the livable city". The Eltis guidelines emphasize that the benefits that the technology will bring do not depend on the technical developments themselves, but on how the transition phase will be managed. For this reason we talk about Cooperative, Connected and Automated Mobility (CCAM), highlighting the need to integrate autonomous vehicles into the existing mobility system, and considering all transport systems, from private vehicles to pedestrian mobility. In particular, the role of Local Public Transport is emphasized, as a solution to respond to the high rates of demand for mobility typical of urban areas. To face this challenge, the guidelines suggest Public Administrations to take action as soon as possible, opening up to dialogue with stakeholders and citizens to build a shared vision. The ultimate goal must be to give priority to urban liveability, avoiding creating cities for the circulation of SDVs only.

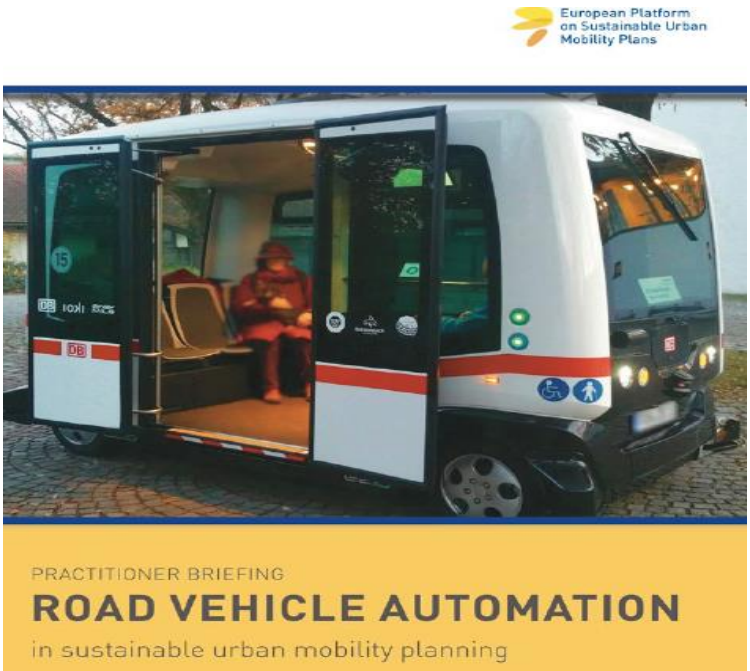

Figure 2*: autonomous vehicle*

4. Conclusions

Given the high uncertainty about the possible effects of technology, it is necessary for the public administration to intervene in order to guide the transition phase. The planning tools, first of all the SUMP, must converge towards the goal of urban liveability, exploiting the potential of SDVs and limiting their negative externalities. To do this, it is necessary to start a new extended governance (in particular between public and private), in order to facilitate collaboration and the creation of a common vision. In addition, some aspects related to the potential of SDV emerge from the research that go beyond traffic flow and road safety.

The European cities could benefit enormously both in terms of accessibility and the quality of public space. These effects depend on how the circulation of autonomous vehicles will be regulated, and in particular whether TPL and sharing will play a relevant role in the diffusion phase.

Nevertheless, at the end of the phase of construction of the policies, it is necessary to evaluate the actions in the global context, also taking into consideration those macro-economic and social phenomena, such as climate change, financial availability of the Public Administration, aging of the population, etc.

However, it is necessary to underline that the regulation of autonomous vehicles will hardly take place for each city, while a standardization of traffic systems and legislation is possible. In this case, it is interesting to promote comparisons among different cities, in such a way that being able to compare how SDV governance can change according to the urban structure and planning tools.

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