Users' Propensity to Use Self-Driving Systems of SAE Automation Level 1 and 2 Cars: Results of an Italian Survey

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Abstract: - The automotive sector is currently developing advanced autonomous functionalities which are expected to be soon integrated into the vehicles. These vehicles can help to reduce road accidents, ease traffic congestion, improve fuel consumption, and reduce pollutant emissions. By contrast, there are still technological, normative, ethical, and social obstacles to the widespread adoption of self-driving cars, among which users' acceptance covers a relevant issue. The aim of the paper was to investigate the users' propensity to use self-driving systems of SAE automation Levels 1 and 2. To do this, an hoc mobility survey was performed in Italy among car drivers, investigating both the presence of these autonomous devices on board the vehicles currently used and their frequency of usage. Survey results show that 41% of the respondents currently have a Level 1 and/or 2 system on-board their car: 54% have only the Cruise Control (Level 1 car), while 46% have both of them (Level 2 car). Furthermore, about 85% of the respondent frequently (medium-high) use the Cruise Control and/or Lane Keeping Assist. More than 86% of the drivers stated that these devices significantly improve both road safety and driving stress (improve the travel experience). The highways are the roads where these self-driving systems are mainly used (more than 70% of the time). These results underline the relevant effort that the automotive industry has performed in the last decades about self-driving. In the last five years within the Italian market was observed an increase of more than 200% of the car standard equipment (no optional) with SAE automation Level 1 or 2 systems.

Key-words: - Self-driving vehicles; driverless; Autonomous Vehicles (AVs); Automated Driving (AD); Artificial Intelligence (AI); Advanced Driver Assistance Systems (ADAS); travel experience; Society of Automotive Engineers (SAE)

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1 Introduction

Europe faces unprecedented environmental, economic, and social challenges. In this context of profound uncertainty, self-driving vehicles, also known as "driverless" or Autonomous Vehicles (AVs), or Automated Driving (AD), represent a significant opportunity and challenge for sustainable mobility. They have the potential to reduce road accidents, alleviate traffic congestion, abate pollutant emissions, reduce fuel consumption, [1], [2], [3], potentially decrease land use, and profoundly modify the scope and boundaries of mobility services (e.g., [4], [5]).

Studies have shown that AVs can have a positive impact on mobility, productivity, and leisure time, [6], [7], as well as on aesthetics with more cutting-edge vehicle design distinct from the current ones. For example, AVs could enhance mobility for individuals who are unable to guide

vehicles due to youthfulness, advanced age, physical disabilities, or other incapacities (e.g., [8], [9], [10], [11], [12]). In addition, AVs offer also a significant opportunity to advance sustainability goals and address current and future challenges in the environmental transition; the adoption of AV technology will lead to optimized driving and technology, through the so-called eco-driving, [2]; with smooth and gradual accelerations and decelerations and lower peak speeds (improving fuel efficiency). The Artificial Intelligence (AI), governing AVs operation, will be capable of ensuring a reduction in pollutant emissions, both in terms of greenhouse gas emissions and particulate matter.

The automotive sector is currently developing advanced autonomous functionalities which are expected to be soon integrated into the vehicles. However, several major obstacles still hinder the widespread adoption of autonomous vehicles (e.g., [13], [14], [15], [16], [17]), including technological, normative, ethical, and social (public acceptance) challenges (e.g., [18]), and other such as high production costs, vehicle usage data security and legal liability (e.g., [19], [20], [21], [22]).

From a technological standpoint, both governments and manufacturers follow the autonomy level classification established by the Society of Automotive Engineers, [23]. The SAE has defined six different levels of automation, ranging from Level 0 (no automation) to Level 5 (fully unrestricted automation). The automation of vehicles occurs at different levels depending on the balance between the role of the driver and that of driving technologies or support. In this regard, automated vehicles and autonomous vehicles are not synonymous, according to the European Commission, [24]: *"automated vehicle is a motor vehicle which has technology available to assist the driver so that elements of the driving task can be transferred to a computer system. While autonomous vehicle is a fully automated vehicle equipped with the technologies capable to perform all driving functions without any human intervention".*

Automated vehicles are fitted with advanced driver assistance systems, known as ADAS, which aid the driver's task and endeavor to avert accidents by intervening when required. This feature enhances road safety. On the other hand, autonomous vehicles take over specific portions of the dynamic driving task, which are ordinarily executed by human drivers. Once engaged, the hardware and software systems analyze the environment and steer the vehicle accordingly. In simpler terms, these vehicles are outfitted with Artificial Intelligence (AI), which involves the study of theoretical principles, methodologies, and techniques for designing hardware systems and software programs that can provide electronic computers with abilities that appear to be the sole domain of human intelligence to an ordinary observer, [25]. As reported by the European Parliament, [26]: *"AI is the ability of a machine to display human-like capabilities such as reasoning, learning, planning and creativity. AI enables technical systems to perceive their environment, deal with what they perceive, solve problems and act to achieve a specific goal. The computer receives data - already prepared or gathered through its own sensors such as a camera - processes it and responds. AI systems are capable of adapting their behaviour to a certain degree by analyzing the effects of previous actions and working autonomously".*

In 2021, SAE International redefined the levels of automation based on the evolution and diffusion of driving functions available in the market, in order to specify when and under what operational design domain (ODD) the dynamic driving task (DDT) activities are performed by the driver and when by the vehicle itself. The new SAE classification highlights the automation progression based on the driver's role in DDT: well-known and now widely available advanced driver assistance systems (ADAS) are functions from level 0 to up to level 2, while automated driving (and the AI) mainly comes in operation with level 3 functions, where the driver must still be ready to intervene, up to levels 4 and 5, where the AI has complete control of the driving task. In other words, according to the new classification, ADAS contribute to automation, which, in addition, leverages Artificial Intelligence to process signals/data received from a combination of sensors, cameras, radar, lidar, laser, GPS locators (and many others), to comprehend the environment and offer a response to challenges, thus ensuring vehicle movement.

As reported in the "Road Safety Thematic Report", [27] the main difference between ADAS and AD is the role of the driver. While ADAS only support the driver with their driving task, AD can take over the complete driving task for at least part of the trip.

From a normative standpoint, numerous trials are underway globally to accelerate the deployment of autonomous vehicles, although fully autonomous vehicles (Levels 4 and 5) are presently prohibited

from being sold in many Countries for legal reasons. Until a few years ago, even experimental testing of autonomous vehicles on public roads was prohibited.

From an ethical perspective, the deployment of autonomous vehicles, as examined in [13], will necessitate ethical deliberations that could engender various quandaries for designers, manufacturers, regulators, and governments. There is a vast scientific literature that addresses the social issue of user acceptance of this new technology, which translates into the level of usage that drivers make of driving aid devices. For example, according to a report by the American Automobile Association in 2017, [28], approximately 75% of Americans expressed apprehension towards utilizing and operating fully autonomous vehicles, corroborating the findings of a previous survey conducted in 2016. Simultaneously, it emerges that 59% of Americans are also eager to have autonomous features on board their next vehicle, demonstrating a strong propensity among Americans to accept this new technology. This result underscores the potential for widespread adoption of autonomous vehicles in the near future, despite existing concerns regarding user acceptance. Research has shown that the acceptance of self-driving vehicles varies across cultures. For instance, [19], discovered that American respondents exhibited greater apprehension towards utilizing autonomous vehicles in comparison to their UK counterparts. According to [29], a significant proportion of UK users (60%) believe that driverless vehicles will enhance the safety of all road users. Similarly, [30], conducted an online survey targeting a large sample of French drivers, revealing that more than half of the respondents expressed an interest in utilizing fully automated vehicles. Surveys conducted in Australia yielded different results. In [31], [32], the authors found that over 70% of respondents in Australia and New Zealand were concerned about riding in a car without a driver. The findings of [19], were also noteworthy. They administered a questionnaire in multiple countries (China, India, Japan, USA, UK, and Australia) and discovered that, regardless of location, 87-95% of respondents were concerned (to varying degrees) about driving or riding in a fully self-driving vehicle.

Starting from these considerations, the paper aimed to investigate the users' propensity to use self-driving systems of SAE automation Levels 1 and 2. To do this, an hoc mobility survey was performed in Italy among car drivers, investigating both the presence of these autonomous devices on board the vehicles and their frequency of usage.

The paper is structured as follows: Section 2 reports the experimental method, Section 3 it is investigated the users' propensity to use self-driving devices of SAE automation Levels 1 and 2 and Section 4 reports the main conclusions, limitations, and future directions.

2 Method

To perform the aim of the research an hoc mobility survey was performed in Italy among the car drivers. A CAWI (Computer-Assisted Web Interviewing) survey was carried out between January and February 2023 among car drivers living in the Provinces of Naples and Caserta in southern Italy.

The questionnaire submitted consisted of two sub-sections:

1. socio-economic background (e.g., age, gender, occupation) and mobility habits (trip frequency, average travel time);
2. presence and level of usage of self-driving systems of SAE automation Levels 1 and 2 with the aim of:
   - investigate the on-board presence of the cruise control and the lane-keeping assist by transmission type (i.e., automatic vs. manual);
   - investigate the frequency of usage of these two autonomous devices by road type (urban, suburban, highway);
   - investigate the users' opinion about the role of the autonomous system (SAE levels 1 and 2) in improving road safety also mitigating driving stress (improving the travel experience).

3 Result and Discussion

Overall, 243 car drivers were interviewed, and Table 1 reports the main survey results: 65% of the sample was male; 65% were 18-40 years old; 71% were employed.

Table 1. Survey results: socio-economic characteristics

	number	*%*
Gender		
male	157	64.61%
female	86	35.39%
Age		
18-30	90	37.04%
30-40	69	28.40%
40-50	48	19.75%
Over 50	36	14.81%
Profession		
Employed	174	71.60%
Not employed	12	4.94%
Student	57	23.46%
Total sample size	**243**	**100.00%**

Results in terms of the presence of SAE Level 1 (Cruise Control or Lane Keeping Assist) and Level 2 (Cruise Control and Lane Keeping Assist) devices on-board the vehicles are reported in Figure 1. 41% of the respondents currently have a Level 1 and/or 2 system on-board their car. Precisely, among those who have them, 54% of the respondents have only the Cruise Control (Level 1 car), while 46% have both the Cruise Control and the Lane keeping assist (Level 2 car).

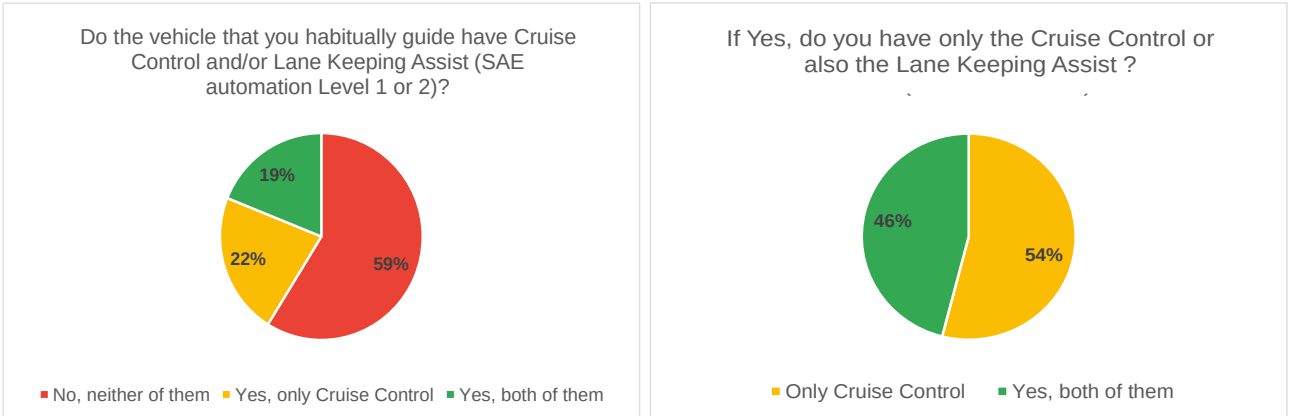

Fig. 1: Survey results: the presence of autonomous devices of SAE automation Levels 1 and 2 on board the vehicles

Figure 2 reports the result in terms of both levels of usage of these self-driving systems and users' perception of their impact on road safety and driving stress. About 85% of the respondent frequently (medium-high) use the Cruise Control and/or Lane Keeping Assist. More than 86% of the driver stated that these devices significantly improve both on-road safety and driving stress. Interestingly is to observe that no differences in usage and/or opinions have been found between Cruise Control and Lane

Keeping Assist users. In addition, Figure 3 shows that the highways are the roads where these self-driving devices are mainly used (more than 70% of the time).

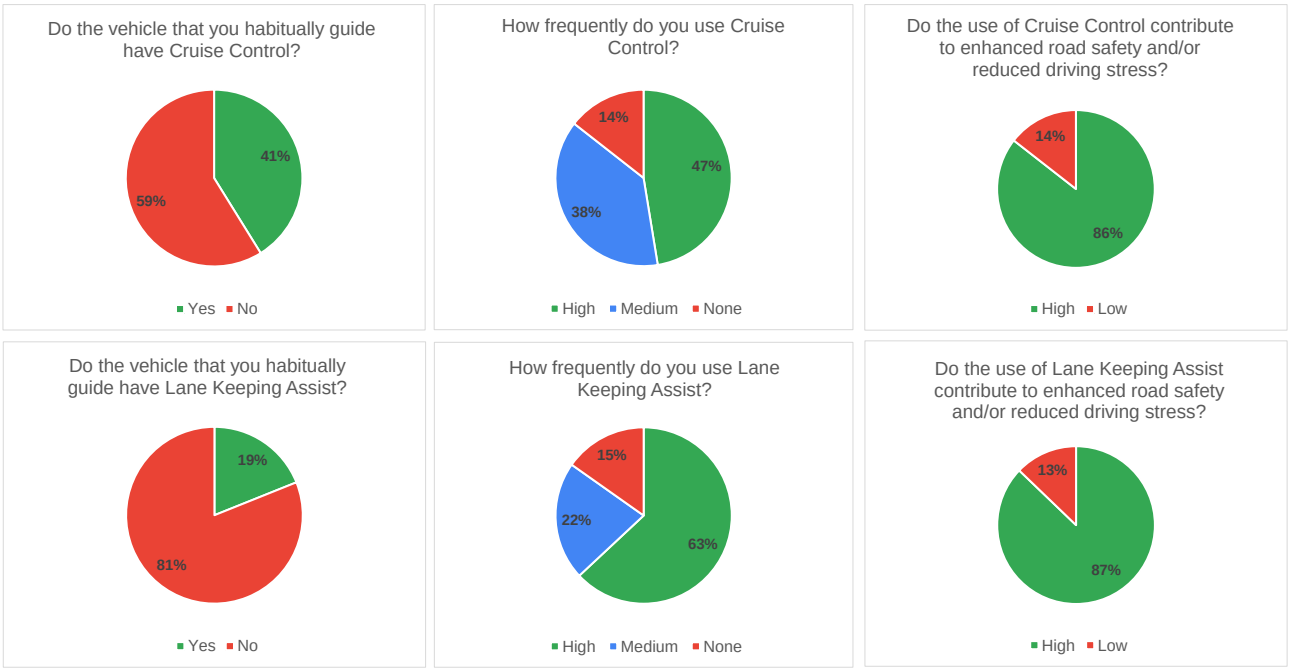

Fig. 2: Survey results: frequency of usage and users' opinion about the role of the autonomous system (SAE level 1 and 2) in improving road safety, also mitigating driving stress (improving the travel experience).

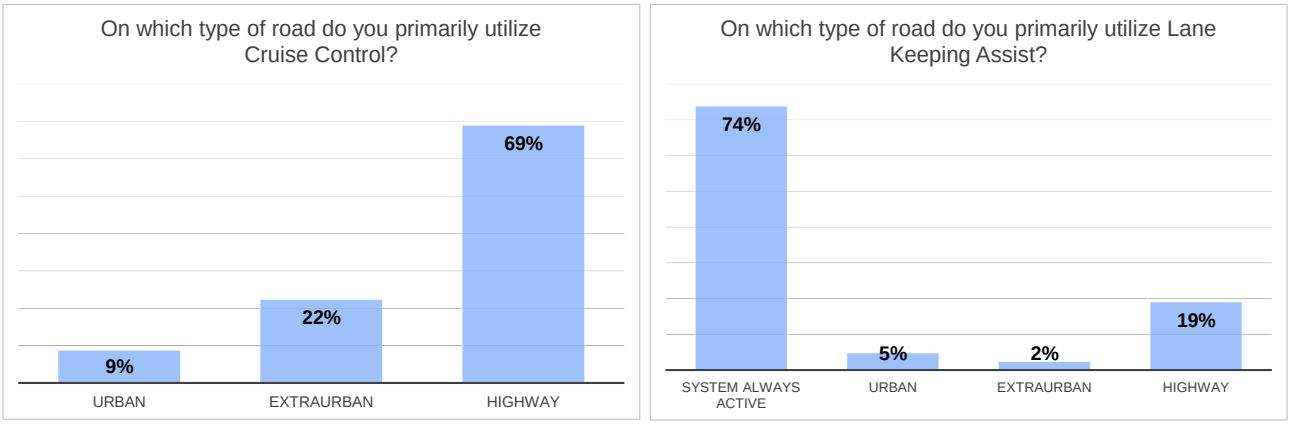

Fig. 3: Survey results: frequency of usage autonomous devices (SAE Level 1 and 2) on board the vehicles by road type (urban, suburban, highway)

Further analysis was conducted to examine possible differences in habits between manual and automatic car transmission users. From the survey emerges that (Figure 4) the presence of Cruise Control (Lane Keeping Assist) in vehicles with automatic transmission is 35 (49) percentage points higher than in a vehicle with a manual transmission. This result is probably related to the circumstance that the car with automatic transmissions has a greater tendency to own more on-board options (such as Cruise Control or Lane Keeping Assist), as the automatic transmission is itself an (expensive) option for the Italian market.

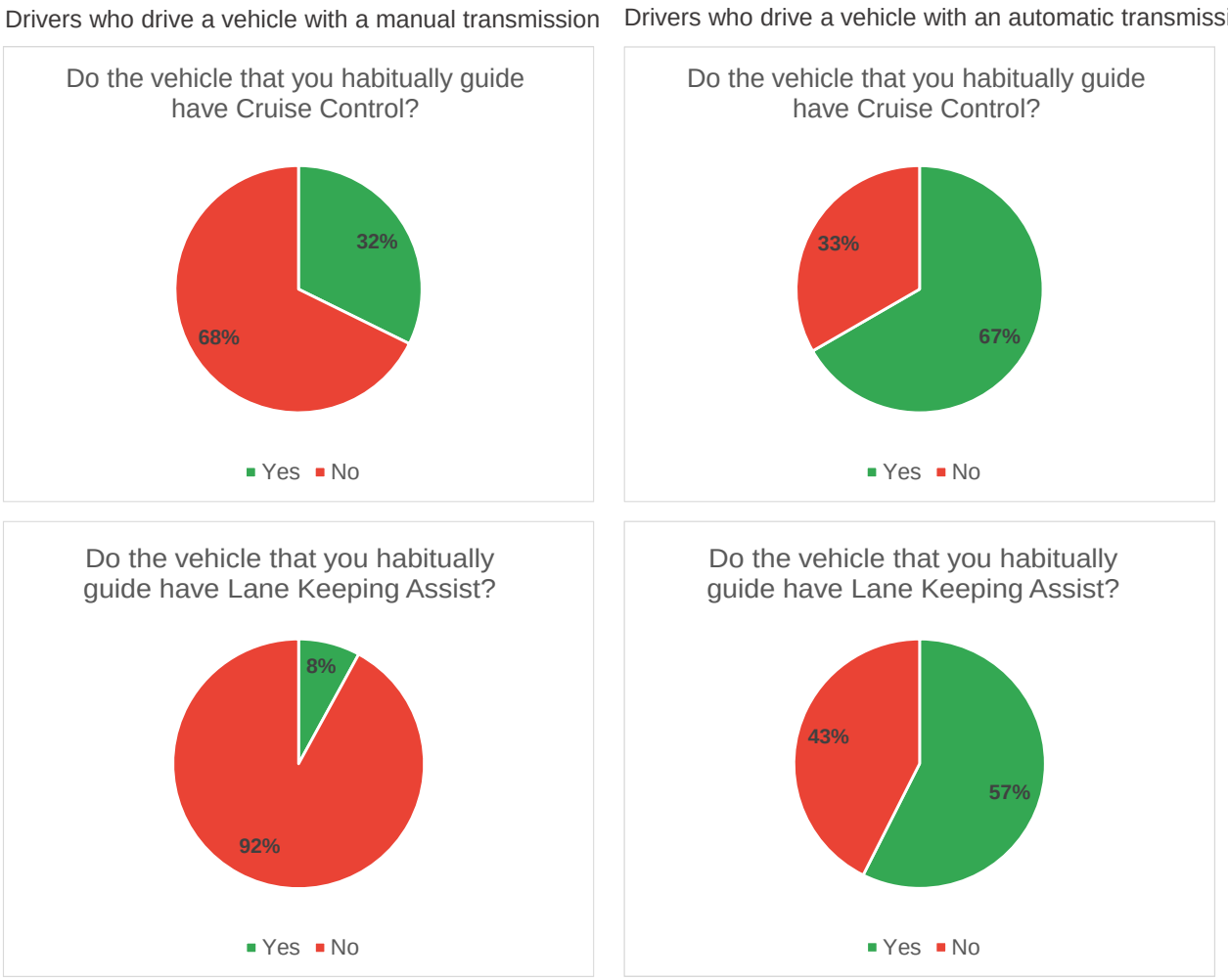

Fig. 4: Survey results: the presence of autonomous devices of SAE automation Level 1 and 2 on board the vehicles by different car transmission (manual vs. automatic) users

In terms of frequency of usage, a significant difference was observed between drivers of automatic transmission cars and those of manual ones (Figure 5); specifically, the former uses Cruise Control and/or Lane Keeping Assist more frequently than the latter (about 7-10 percentage points more). Finally, both these categories of drivers agree that SAE Level 1 and 2 systems significantly reduce driving stress and increase road safety (Figure 6).

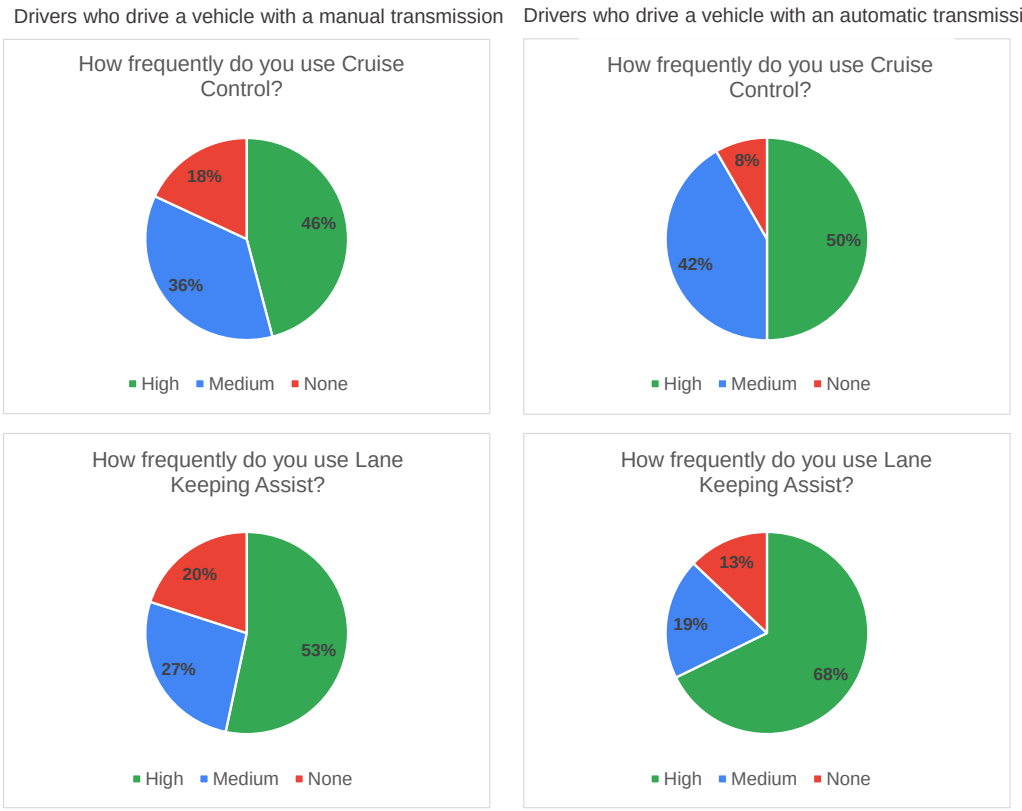

Fig. 5: Survey results: frequency of usage of autonomous system (SAE level 1 and 2) by car transmission type (manual and automatic)

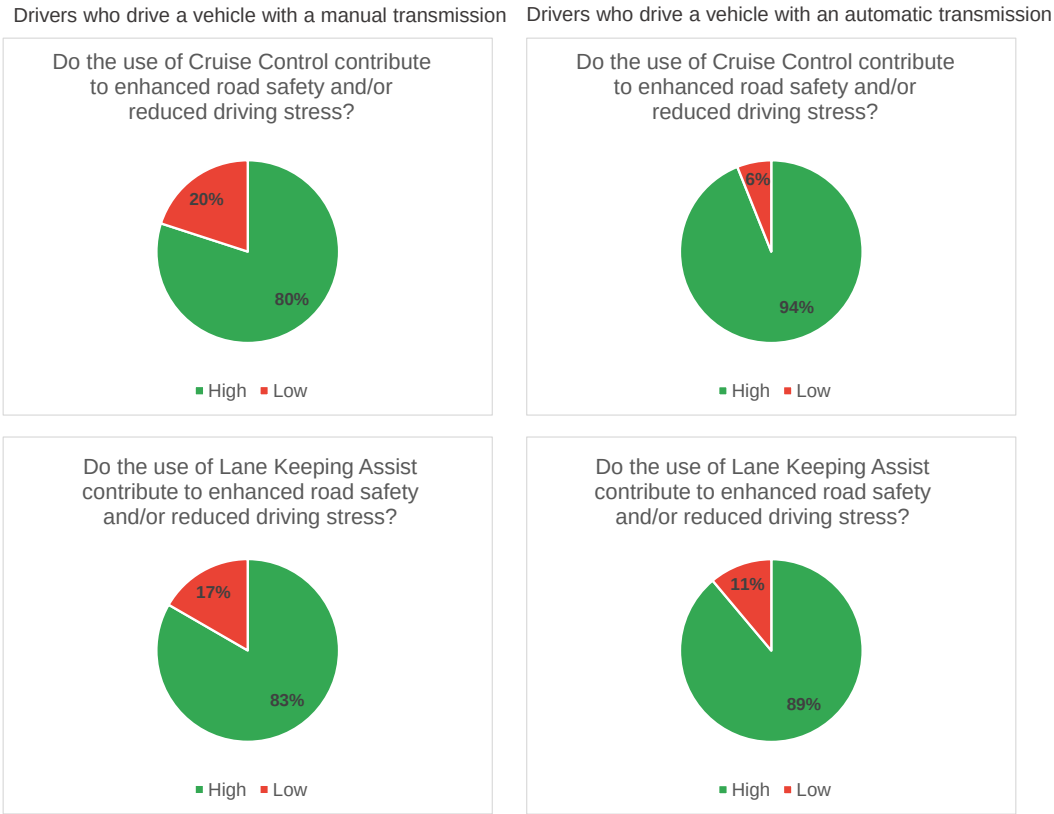

Fig. 6: Survey results: users' opinion about the role of the autonomous system (SAE Level 1 and 2) in improving road safety, also mitigating driving stress (improving the travel experience) by car transmission type (manual and automatic)

4 Conclusion

Autonomous mobility, together with e-mobility (e.g., [33], [34], [35]) and smart roads (e.g., [36], [37], [38]), can significantly contribute to sustainable mobility and decarbonization of the transport sector. AVs offer an important opportunity to advance sustainability goals and address current and future challenges in the environmental transition, as they have the potential to ensure a reduction in pollutant emissions, both in terms of greenhouse gas emissions and particulate matter, reduce road accidents, alleviate traffic congestion, and reduce fuel consumption.

The automation of vehicles occurs at different levels depending on the balance between the role of the driver and that of driving technologies that support the guide. In the last five years, a massive penetration into the market of advanced autonomous functionalities have occurred. Their market penetration is dependent on both technological innovation and user acceptance, which is contingent upon their willingness to utilize and trust this emerging technology.

Starting from these considerations, the paper investigated the users' propensity to use self-driving systems of SAE automation Levels 1 and 2. Estimation results show that 41% of the respondents currently have a Level 1 and/or 2 system on-board their car: 54% have only the Cruise Control (Level 1 car), while 46% have both of them (Level 2 car). Furthermore, about 85% of the respondent frequently (medium-high) use the Cruise Control and/or Lane Keeping Assist. More than 86% of the drivers stated that these devices significantly improve both on road safety and driving stress. Finally, the highways are the roads where these self-driving devices are mainly used (more than the 70% of the times).

These results underline the relevant effort that the automotive industry has performed in the last decades to integrate advanced autonomous functionalities on-board the vehicles. On this issue, within the Italian market, in the last five years, an increase of 209% of the car with SAE automation Level 1 and 2 (Cruise Control and/or Lane Keeping Assist) as standard equipment (not optional) was observed.

Future perspectives will be to evaluate the sustainability of self-driving mobility in terms of possible market penetration scenarios through, for example, cost-benefit or multi-criteria analysis (e.g., [39], [40]), also within rational transportation planning decision-making processes (e.g., [41], [42]).

References:

[1] European Commission, White paper: roadmap to a single European transport area-towards a competitive and resource efficient transport system, COM, 2011, 144.

[2] Bagloee, S. A., Tavana, M., Asadi, M., & Oliver, T., Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. *Journal of modern transportation*, 24, 2016, pp. 284-303.

[3] Morrison, G., and Van Belle, J. P., Customer intentions towards autonomous vehicles in South Africa: an extended UTAUT Model. *In 2020 10th International Conference on Cloud Computing, Data Science & Engineering (Confluence)*, IEEE, 2020, pp. 525-531.

[4] Akar, G., and Erhardt, G. D., User response to autonomous vehicles and emerging mobility systems. *Transportation*, 45, 2018, pp. 1603-1605.

[5] Fagnant, D. J., and Kockelman, K. M., Dynamic ride-sharing and fleet sizing for a system of shared autonomous vehicles in Austin, Texas. *Transportation*, 45, 2018, pp. 143-158.

[6] Eugensson, A., Brännström, M., Frasher, D., Rothoff, M., Solyom, S., & Robertsson, A., Environmental, safety legal and societal implications of autonomous driving systems. *In International Technical Conference on the Enhanced Safety of Vehicles (ESV)*. Seoul, South Korea, 2013, Vol. 334.

[7] Krueger, R., Rashidi, T. H., & Rose, J. M., Preferences for shared autonomous vehicles. *Transportation research part C: emerging technologies*, *69*, 2016, pp. 343-355.

[8] Harper, C. D., Hendrickson, C. T., Mangones, S., & Samaras, C., Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions. *Transportation research part C: emerging technologies*, *72*, 2016, pp. 1-9.

[9] N. H. T. S., Automated driving systems 2.0: A vision for safety. *Washington, DC: US Department of Transportation, DOT HS*, *812*, 2017, 442.

[10] Bennett, R., Vijaygopal, R., & Kottasz, R., Attitudes towards autonomous vehicles among people with physical disabilities. *Transportation research part A: policy and practice*, *127*, 2019, pp. 1-17.

[11] Hwang, J., Li, W., Stough, L., Lee, C., & Turnbull, K., A focus group study on the potential of autonomous vehicles as a viable transportation option: Perspectives from people with disabilities and public transit agencies. *Transportation research part F: traffic psychology and behaviour*, *70*, 2020, pp. 260-274.

[12] Lee, Y. C., & Mirman, J. H., Parents' perspectives on using autonomous vehicles to enhance children's mobility. *Transportation research part C: emerging technologies*, *96*, 2018, pp. 415-431.

[13] Bonnefon, J. F., Shariff, A., & Rahwan, I., The social dilemma of autonomous vehicles. *Science*, *352*(6293), 2016, pp. 1573-1576.

[14] Cascetta, E., Cartenì, A., Di Francesco, L., Do autonomous vehicles drive like humans? A Turing approach and an application to SAE automation Level 2 cars. *Transportation Research Part C: Emerging Technologies*, 2022, 134.

[15] European Transport Safety Council, Prioritising the safety potential of automated driving in Europe, 2016.

[16] Fagnant, D. J., & Kockelman, K., Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy and Practice*, *77*, 2015, pp. 167-181.

[17] Shariff, A., Bonnefon, J. F., & Rahwan, I., Psychological roadblocks to the adoption of self-driving vehicles. *Nature Human Behaviour*, *1*(10), 2017, pp. 694-696.

[18] Cartenì, A., The acceptability value of autonomous vehicles: A quantitative analysis of the willingness to pay for shared autonomous vehicles (SAVs) mobility services. *Transportation Research Interdisciplinary Perspectives*, *8*, 2020, 100224.

[19] Schoettle, B., and Sivak, M., *Public opinion about self-driving vehicles in China, India, Japan, the US, the UK, and Australia*. University of Michigan, Ann Arbor, Transportation Research Institute, 2014

[20] KPMG, 2013. Self-Driving Cars: Are we ready? Retrieved from <http://www.kpmg.com/US/en/IssuesAndInsights/ArticlesPublications/Documents/selfdriving-cars-are-we-ready.pdf>.

[21] Howard, D., & Dai, D., Public perceptions of self-driving cars: The case of Berkeley, California. In *Transportation research board 93rd annual meeting*, Washington, DC: The National Academies of Sciences, Engineering, and Medicine, 2014, Vol. 14, No. 4502, pp. 1-16.

[22] Haboucha, C. J., Ishaq, R., & Shiftan, Y., User preferences regarding autonomous vehicles. *Transportation Research Part C: Emerging Technologies*, *78*, 2017, pp. 37-49.

[23] SAE, 2014. On-Road Automated Vehicle Standards Committee (Taxonomy and Definitions for Terms Related to On-road Motor Vehicle Automated Driving Systems).

[24] European Commission, Automated vehicles in the EU, https://www.europarl.europa.eu

[25] Somalvico, *Artificial Intelligence*, Hewlett-Packard, 1987

[26] European Parliament, what is artificial intelligence and how is it used?, https://www.europarl.europa.eu/

[27] European Road Safety Observatory, Road Safety Thematic Report, *Advanced driver assistant system*, December 2021

[28] American Automobile Association, 2017. Americans Feel Unsafe Sharing the Road With Fully Self-driving Vehicles. Retrieved from. http://go.nature.com/2i296OW

[29] Begg, D. A 2050 vision for London: what are the implications of driverless transport? 2014

[30] Payre, W., Cestac, J., & Delhomme, P., Intention to use a fully automated car: Attitudes and a priori acceptability. *Transportation research part F: traffic psychology and behaviour*, *27*, 2014, pp. 252-263.

[31] Cunningham, M. L., Ledger, S. A., & Regan, M., A survey of public opinion on automated vehicles in Australia and New Zealand. In *28th ARRB International Conference–Next Generation Connectivity, Brisbane, Queensland*, 2018.

[32] Regan, M.A., Cunningham, M., Dixit, V., Horberry, T., Bender, A., Weeratunga, K., Cratchley, S., Dalwood, L., Muzorewa, D., Hassan, A., Preliminary Findings fromthe First Australian National Survey of Public Opinion about Automated and Driverless Vehicles. Australian and New Zealand Driverless Vehicle Initiative, Adelaide, Australia (987-1-876592-85-1), 2017.

[33] Carteni, A., Henke, I. , Molitierno, C., Errico, A., Towards E-mobility: Strengths and Weaknesses of Electric Vehicle;

Advances in Intelligent Systems and Computing Volume 1150 AISC, *Workshops of the 34th International Conference on Advanced Information Networking and Applications*, WAINA, 2020; Caserta, Italy; pp. 1383-1393.

[34] Ruggieri, R., Ruggeri, M., Vinci, G., & Poponi, S., Electric mobility in a smart city: European overview. *Energies*, *14*(2), 2021, 315.

[35] Babar, A. H. K., Ali, Y., & Khan, A. U., Moving toward green mobility: overview and analysis of electric vehicle selection, Pakistan a case in point. *Environment, Development and Sustainability*, *23*, 2021, 10994-11011.

[36] Henke I., Bifulco G.N., Carteni A., Di Francesco L., Di Stasio A., A Smart Road Application: The A2 Mediterranean Highway Project in Italy. In Barolli L., Woungang I., Enokido T. (eds), *35th International Conference on Advanced Information Networking and Applications*, AINA, 2021. Lecture Notes in Networks and Systems, 227, pp. 690 – 700.

[37] Zawieska, J., and Pieriegud, J., Smart city as a tool for sustainable mobility and transport decarbonisation. *Transport policy*, *63*, 2018, pp. 39-50.

[38] Torrisi, V., Ignaccolo, M., & Inturri, G., Innovative transport systems to promote sustainable mobility: Developing the model architecture of a traffic control and supervisor system. In *Computational Science and Its Applications–ICCSA 2018: 18th International Conference, Melbourne, VIC, Australia, July 2–5, 2018, Proceedings, Part III 18, 2018,* (pp. 622-638). Springer International Publishing.

[39] Carteni', A., Henke, I., Molitierno, C., A cost-benefit analysis of the metro line 1 in Naples, Italy; *WSEAS Transactions on Business and Economics*, 15, 2018, pp. 529-538.

[40] Cartenì A., Henke, I. Di Francesco L., A sustainable evaluation processes for investments in the transport sector: A combined multi-criteria and cost–benefit analysis for a new highway in Italy. *Sustainability*, Vol 12, Issue 23, 9854, 2020, pp. 1-27.

[41] Cartenì, A., Marzano, V., Henke, I., Cascetta, E., A cognitive and participative decision-making model for transportation planning under different uncertainty levels. *Transport Policy*, 116, 2022, pp. 386-398.

[42] Cartenì, A., Updating demand vectors using traffic counts on congested networks: A real case application, *WIT Transactions on the Built Environment* 96, 2007, pp. 211-221.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

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Conflict of Interest

The authors have no conflict of interest to declare.