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Review Paper

Society 5.0 – the role of the automotive industry

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***Abstract**: The simultaneous development and aging of society in Japan led to the idea of creating Society 5.0. The integration of physical and virtual space with the aim for the prosperity and safety of each individual represents the concept of the organization of society, which is called Society 5.0. In terms of mobility, which is one of the key areas in society organization, solutions are being explored to enable the use of autonomous vehicles and alternative transportation options. Additionally, advanced technologies in the automotive industry that focus on the needs of vehicle users and workers in the automotive industry are being specifically researched.*

***Keywords**: Society 5.0, mobility, autonomous vehicles, advanced technologies*

Društvo 5.0 – uloga automobilske industrije

***Apstrakt**: Istovremeno starenje i razvoj društva u Japanu doveli su do ideje o stvaranju Društva 5.0. Integracija fizičkog i virtuelnog prostora u cilju blagostanja i sigurnosti svakog pojedinca predstavlja koncept organizacije društva koji se naziva Društvo 5.0. Sa aspekta mobilnosti, kao jedne od ključnih oblasti u organizaciji društva, istražuju se rešenja pomoću kojih se može realizovati korišćenje autonomnih vozila i alternativnih mogućnosti transporta. Takođe, posebno se istražuju napredne tehnologije iz oblasti automobilske*

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industrije koje su fokusirane na potrebe korisnika motornih vozila i radnika u industriji.

***Ključne reči**: Društvo 5.0, mobilnost, autonomna vozila, napredne tehnologije*

1. Introduction

Population aging impact society in many ways, including economic, social, and cultural impacts. For example, as the proportion of elderly in the population increases, there may be a pressure on pension system, healthcare system, and social support system. There may also be changes in the labor market, as elderly workers may remain in the workforce for longer period of time and there may be a need for retraining and reskilling to adapt to new technologies and changing economic conditions. Society 5.0 aims to use advanced technologies to address these challenges and to create a more sustainable, inclusive, and resilient society. By harnessing the power of technology, it is hoped that it will be possible to enhance the quality of life for all members of society, including elderly, and to create a more harmonious and prosperous society for all.

Society 5.0 is a concept of society organization that originated in Japan, based on the need for advanced integration of virtual and physical space. In this way, a balance of economic progress would be achieved while solving various social problems and enabling the creation of a human-centered society.

- Society 1.0 (Hunter-gatherer Society) represents the beginning of the development of humanity when the primary goals were hunting and gathering food.
- Society 2.0 (Agrarian Society) represents the beginning of growing plant crops, primarily for the purpose of feeding people, that is, it represents the beginning of farming.
- Society 3.0 (Industrial Society) includes the beginning of the industrialization of society.
- Society 4.0 (Information Society) represents a society with large amount of available information, which is of great importance for its functioning.

The humans have achieved population growth and economic progress by adopting various technologies and improving productivity. On the other hand, various social problems that are difficult to solve began to manifest. Society 4.0 is based on the availability of information and computer networks. Further progress towards society 5.0 includes the unification of virtual and physical space, which will lead to the creation of new values, in order to enable the overcoming of social problems with economic progress. Current knowledge and information are available to everyone, but it is difficult to establish their

classification. Society 5.0 will use artificial intelligence to replace people in the demanding search for a large amount of information in order to find the desired or needed data. Each type of data will be collected through sensors placed in physical space and connected via the Internet. With the help of robots, autonomous vehicles and other similar technologies, everyday work activities will be made easier for everyone.

One of the main tasks of Society 5.0 is, as mentioned earlier, to provide solutions to various social problems along with economic progress. With economic progress comes increased demand for various energy sources and food products, so it is necessary to ensure the reduction of environmental pollution, which is a consequence of increased energy consumption and food production. Since economic progress also leads to an increase in life expectancy, it is necessary to ensure that the costs associated with an aging population are reduced. Economic progress can also lead to the concentration of wealth and regional inequality, so one of the tasks of Society 5.0 is to ensure the redistribution of wealth and thereby reduce the differences between different regions in order to solve this problem. Therefore, a very important task of Society 5.0 is to establish a certain balance between economic progress and solving social problems. Society 5.0 brings benefits for everyone, regardless of age group or gender. Comfort is increased, and a healthier lifestyle is encouraged. People are also freed from a large part of the simple work and in this way a better use of working time is made possible. In other words, the goal is to achieve a higher quality of life that would also become much safer and more secure.

The most common definition of Society 5.0 is that this society is a human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space (Cabinet Office, Government of Japan, 2023).

2. Society 5.0 in different spheres of life

2.1. Healthcare and Caregiving

Healthcare in Society 5.0 refers to the use of advanced technologies and innovative approaches to improve the quality, accessibility, and efficiency of healthcare services. It aims to address global challenges such as the increasing prevalence of chronic diseases, an aging population, and a shortage of healthcare professionals. Some of the key technologies and approaches used in Society 5.0 healthcare include (Cabinet Office, Government of Japan, 2023):

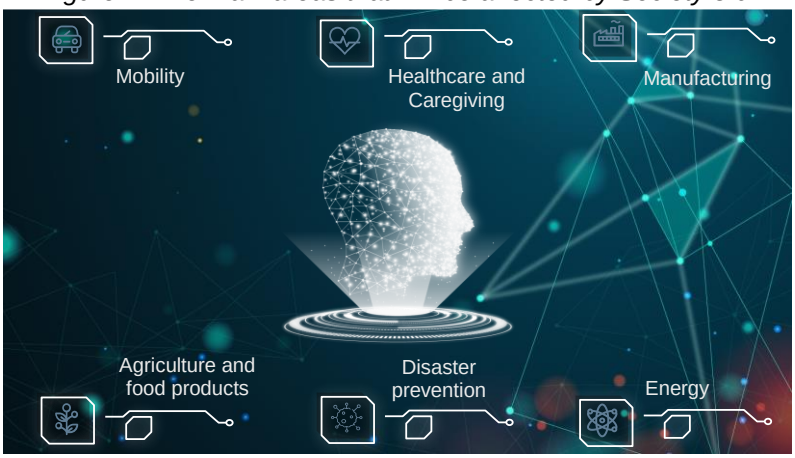
- Telemedicine: This involves the use of telecommunication technologies, such as videoconferencing, to provide remote medical

consultation and support. Telemedicine can help patients access care from anywhere, and can reduce the need for in-person visits to healthcare facilities.

- Wearable and remote monitoring devices: These devices, such as smartwatches and sensors, can be worn by patients to continuously monitor their vital signs and other health indicators. The data collected by these devices can be used to detect early signs of illness or deterioration, and can help healthcare professionals intervene before a condition becomes serious.
- Artificial intelligence and machine learning: These technologies can be used to analyze large amounts of data, such as electronic health records, to identify patterns and make predictions about patients' health. They can also be used to support diagnosis and treatment decisions, and to improve the efficiency of healthcare services.
- 3D printing: This technology can be used to create customized medical devices and implants, such as prosthetics and hearing aids. It can also be used to create models of patients' organs, which can be used for surgical planning and training.

In addition to healthcare and caregiving, other areas that Society 5.0 will focus on are shown in Figure 1.

Figure 1. The main areas that will be affected by Society 5.0



2.2. Manufacturing

In Society 5.0, manufacturing is expected to become more efficient, sustainable, and flexible, thanks to the adoption of advanced technologies and

innovative approaches. Some of the key technologies and approaches that are likely to be used in Society 5.0 manufacturing include (Cabinet Office, Government of Japan, 2023):

- Additive manufacturing: Also known as 3D printing, this technology allows companies to create customized products by building them layer by layer from a variety of materials. Additive manufacturing can reduce waste generation and need for large inventories, and also can make it easier to produce small batches of customized products.
- Robotics and automation: The use of robots and automated systems can help companies increase efficiency and reduce the need for labor. These technologies can be used for tasks such as assembly, inspection, and packaging.
- Internet of Things (IoT): The IoT refers to the network of connected devices that can communicate with each other and with central systems. In manufacturing, the IoT can be used to monitor and control production processes, and to collect data that can be used to optimize operations.
- Artificial intelligence and machine learning: These technologies can be used to analyze data from sensors, robots, and other sources to identify patterns and make predictions about production processes. They can also be used to optimize supply chains and improve the efficiency of manufacturing operations.

2.3. Agriculture and food products

In Society 5.0, agriculture and food production are likely to be transformed by the adoption of advanced technologies and innovative approaches that aim to increase efficiency, sustainability, and safety (Cabinet Office, Government of Japan, 2023). Some of the key technologies and approaches that are likely to be used in Society 5.0 agriculture and food production include (Cabinet Office, Government of Japan, 2023):

- Precision agriculture: This involves the use of sensors, GPS, and other technologies to optimize farming practices, such as irrigation, fertilization, and pest control. Precision agriculture can help farmers increase yields and reduce the use of resources such as water and pesticides.
- Vertical farming: This refers to the practice of growing crops in stacked layers, using artificial light and hydroponics to create optimal growing conditions. Vertical farming can be done in urban areas, and requires less land, water, and pesticides than traditional farming methods.
- Plant-based and lab-grown meat: These alternatives to traditional meat can be produced using less land, water, and energy, and may have a

lower environmental impact than traditional livestock production. Plant-based meat is made from plant proteins, while lab-grown meat is produced by growing cells in a laboratory setting.

- Food waste reduction: In Society 5.0, there is likely to be a greater focus on reducing food waste and increasing the efficiency of the food supply chain. This could involve using technology to optimize food production and distribution, and to reduce spoilage and waste.

2.4. Disaster prevention

In Society 5.0, disaster prevention is likely to be aided by the use of advanced technologies and innovative approaches that aim to increase the resilience and preparedness of communities and systems. Some of the key technologies and approaches that are likely to be used in Society 5.0 disaster prevention include (Cabinet Office, Government of Japan, 2023):

- Predictive analytics: This involves using data, such as weather patterns and sensor readings, to identify patterns and make predictions about potential disasters. Predictive analytics can help communities and governments take preventive measures before disasters occur, such as evacuating areas at risk or reinforcing infrastructure.
- Early warning systems: These systems use sensors, such as seismometers and weather stations, to detect potential disasters and alert authorities and the public. Early warning systems can help people evacuate or take other protective measures before disasters occur.
- Drones and robots: Drones and robots can be used to gather data and assess damage after disasters occur. They can also be used to deliver supplies and aid to affected areas, especially in cases where it is difficult for humans to access.
- Artificial intelligence and machine learning: These technologies can be used to analyze data from sensors, drones, and other sources to identify patterns and make predictions about potential disasters. They can also be used to optimize disaster response and recovery efforts.

2.5. Energy

In Society 5.0, energy is likely to be generated, distributed, and used in more efficient and sustainable ways, thanks to the adoption of advanced technologies and innovative approaches. Some of the key technologies and approaches that are likely to be used in Society 5.0 energy include (Cabinet Office, Government of Japan, 2023):

- Renewable energy: This includes energy sources such as solar, wind, and hydro power, which are abundant and emit little or no greenhouse

gases. In Society 5.0, there is likely to be a greater reliance on renewable energy, as it is more sustainable and less polluting than fossil fuels.

- Smart grids: These are electricity networks that use sensors, automation, and other technologies to optimize the distribution and use of energy. Smart grids can help balance supply and demand, reduce energy waste, and improve the reliability of the power grid.
- Energy storage: In Society 5.0, there is likely to be a greater focus on developing technologies that can store excess renewable energy for use when it is needed. This could include batteries, pumped hydro storage, and other technologies.
- Energy efficiency: In Society 5.0, there is likely to be a greater emphasis on improving the efficiency of energy use, which can help reduce greenhouse gas emissions and save money. This could involve using more efficient appliances and buildings, and adopting practices such as carpooling and telecommuting.

3. Mobility

3.1. Current problems in the field of mobility

There are many current problems in the field of mobility, including traffic congestion, lack of accessibility, environmental impact, safety, affordability, and integration with other modes of transportation. In many cities, there is a high level of traffic congestion, which can lead to longer travel times and increased air pollution. Many transportation systems are not accessible to people with disabilities and senior citizens, making it difficult for them to get around. Additionally, transportation plays a significant role in greenhouse gas emissions and air pollution, and finding ways to decrease these impacts is a one of crucial challenges. Road accidents are a major cause of death and injury, and improving the safety of transportation systems is a major concern (World Health Organization, 2021).

Transportation can also be costly, so finding ways to make transportation more affordable is also essential. Many cities have various modes of transportation, such as cars, buses, trains, and bikes, and improving the integration and efficiency of these different modes is a key challenge.

3.2. Mobility in Society 5.0

In Society 5.0 mobility issues will be addressed through a combination of technological solutions and policy changes. Potential solutions to address

these issues include the use of autonomous vehicles which have the potential to significantly reduce traffic congestion and improve safety on the roads. Improving public transportation systems, such as buses and trains, can also make it easier for people to get around without relying on personal vehicles, which can help reduce congestion and environmental impacts. The development of alternative modes of transportation, such as electric scooters, e-bikes, and shared bikes, can provide more options for people to get around and reduce the reliance on personal vehicles. Infrastructure improvements, such as building dedicated lanes for buses and bikes, can make it easier and more convenient for people to use alternative modes of transportation. The integration of advanced technologies, such as real-time traffic monitoring and dynamic routing, can help optimize the use of transportation systems and make them more efficient.

Vehicle convoys and drones are two examples of technologies that could potentially be used to address mobility issues in Society 5.0. Vehicle convoys, also known as "platoons", involve a group of connected vehicles that follow a lead vehicle (a truck) closely, with the goal of reducing fuel consumption and improving safety. Drones, or unmanned aerial vehicles, have the potential to be used for a variety of transportation-related tasks in Society 5.0. For example, drones could be used to deliver packages or goods, or to provide on-demand transportation services. Drones could also be used to inspect infrastructure or monitor traffic conditions. It is important to note that the use of these technologies would likely be subject to regulatory and technical constraints, and their adoption would depend on various factors such as cost, safety, and public acceptance.

3.3. Autonomous vehicles as a key factor of mobility in Society 5.0

Autonomous vehicles are expected to play a significant role in Society 5.0, as they have the potential to greatly improve the efficiency and safety of transportation systems.

One key advantage of autonomous vehicles is their ability to improve traffic flow and reduce congestion on the roads. Autonomous vehicles can communicate with each other and with infrastructure to optimize routes and avoid traffic jams, leading to faster travel times and reduced energy consumption. Autonomous vehicles can also operate more efficiently than human-driven vehicles, as they can make precise adjustments to speed and spacing, and they do not get tired or distracted.

Another key advantage of autonomous vehicles is their potential to improve safety on the roads. Autonomous vehicles can detect and respond to hazards more quickly and accurately than humans, and they do not get distracted or impaired by alcohol or other substances. Autonomous vehicles could potentially

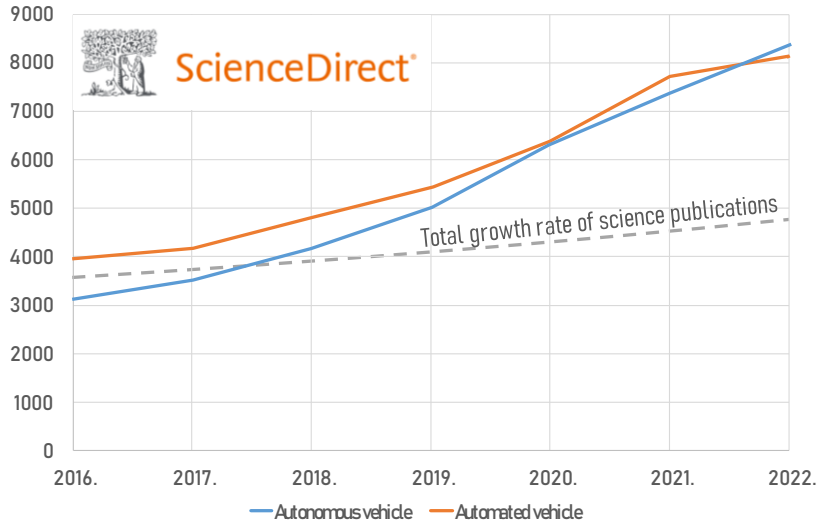
eliminate a significant portion of the traffic accidents that are currently caused by human error. In addition to these benefits, autonomous vehicles could also provide accessibility benefits for people who are unable to drive due to age, disability, or other factors. Autonomous vehicles could also provide economic benefits by reducing the cost of transportation for individuals and businesses.

Engineers can play a key role in making autonomous vehicles more trustworthy by designing and testing systems and technologies that meet rigorous safety standards and perform reliably in a variety of conditions. Some specific ways in which engineers can make autonomous vehicles more trustworthy include:

- Ensuring that autonomous vehicles have robust sensing and perception capabilities: Autonomous vehicles rely on sensors and algorithms to perceive and understand their environment. Engineers can design and test sensors and algorithms to ensure that they can accurately detect and classify objects, pedestrians, and other hazards, and that they can perform reliably in a variety of lighting and weather conditions.
- Developing robust control systems: Autonomous vehicles need to be able to make safe and efficient decisions in real-time, based on their perception of the environment. Engineers can design and test control systems that can safely and reliably navigate through complex and dynamic environments, and that can handle edge cases and unexpected events.
- Ensuring that autonomous vehicles are thoroughly tested and validated: Autonomous vehicles need to be tested and validated in a variety of conditions to ensure that they are safe and reliable. Engineers can design and conduct testing programs that simulate a wide range of scenarios and conditions, and that use statistical methods to demonstrate the reliability of autonomous vehicles.
- Implementing robust cybersecurity measures: Autonomous vehicles are vulnerable to cyber attacks, which could compromise their safety or functionality. Engineers can design and implement cybersecurity measures that protect autonomous vehicles from hacking and other threats, and that ensure the integrity and confidentiality of the data they generate.
- Engaging with regulators, policymakers, and other stakeholders: Engineers can work with regulators, policymakers, and other stakeholders to develop standards, guidelines, and best practices for the design, testing, and deployment of autonomous vehicles. They can also help to educate the public and other stakeholders about the capabilities and limitations of autonomous vehicles, and about the measures that are being taken to ensure their safety. In the Republic of Serbia, many conferences are held, where one of the regular topics

is the development and regulation of autonomous (Stamenković, Popović & Blagojević, 2016) and electric vehicles (Stamenković & Blagojević, 2022).

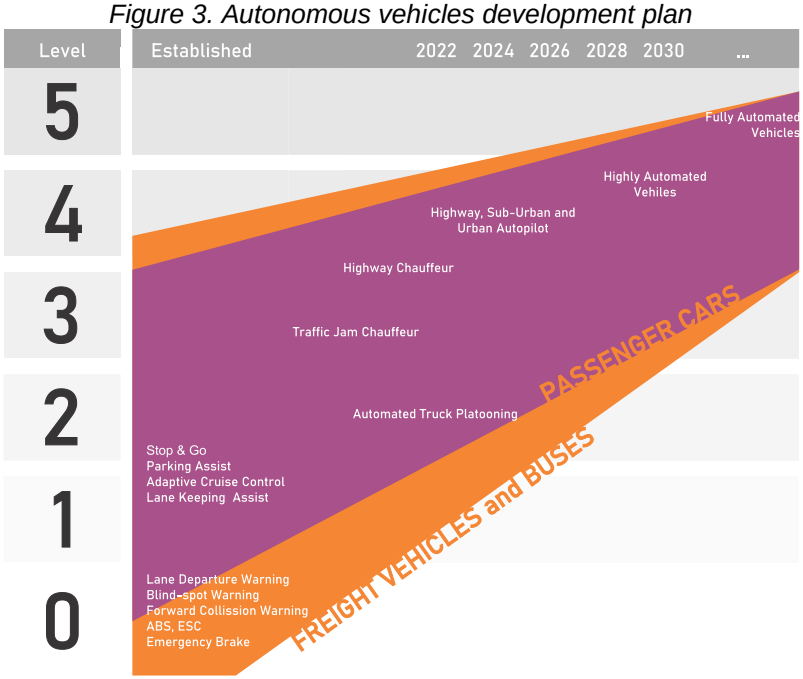
Figure 2. Increasing number of scientific papers published in the field of autonomous vehicles



Source: (Stamenković, 2022) and (Bornmann, Haunschild & Mutz, 2021)

There has been a significant increase in the number of scientific papers published in the field of autonomous vehicles in recent years, as shown in Figure 2. This trend reflects the growing importance of autonomous vehicles as technology and societal issue. There has also been a trend towards interdisciplinary research in the field of autonomous vehicles, as the technology touches on many different areas, including computer science, electrical, mechanical and transportation engineering. Development plan of the autonomous vehicles is shown in Figure 3.

Figure 3. Autonomous vehicles development plan



Source: (European Road Transport Research Advisory Council, 2019)

4. The importance of mobility in Society 5.0 for senior citizens

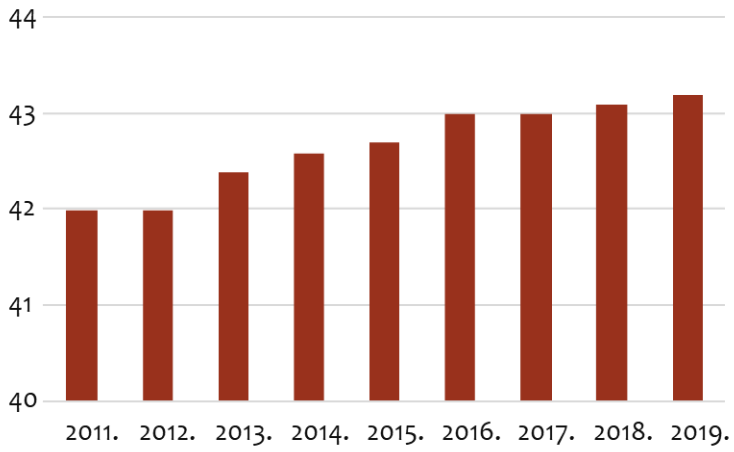
In Society 5.0, mobility solutions have the potential to greatly benefit senior citizens. Some specific ways in which this could occur include improved accessibility, increased safety, greater independence, reduced transportation costs, and enhanced social connections. Autonomous vehicles and other advanced technologies could make transportation more accessible for seniors who may have mobility or vision issues, or who may no longer be able to drive. Autonomous vehicles and other advanced technologies have the potential to greatly improve safety on the roads, which could be especially beneficial for seniors who may be more vulnerable in the event of a collision. Mobility solutions in Society 5.0 could allow senior citizens to maintain their independence and continue to participate in activities and events outside of their homes, even if they are unable to drive. Shared mobility solutions, such as ride-hailing or carpooling services, could potentially reduce the cost of transportation for seniors, who may have fixed incomes or limited financial

resources. Mobility solutions in Society 5.0 could help seniors stay connected to their communities and maintain social connections, which is important for their physical and mental health.

One of the main drivers behind the development of the concept of Society 5.0 in Japan was the country's rapidly aging population. Japan has one of the oldest populations in the world, with a large proportion of the population being over the age of 65. This demographic trend has presented a number of challenges for the country, including a declining birth rate and a shrinking labor force.

The trend of an increasingly aging population is also case in the Republic of Serbia. According to the Statistical Office of the Republic of Serbia, the population has aged by more than one year in the previous 10 years, as shown in Figure 4 (Statistical Office of the Republic of Serbia, 2022).

Figure 4. Average age in the Republic of Serbia



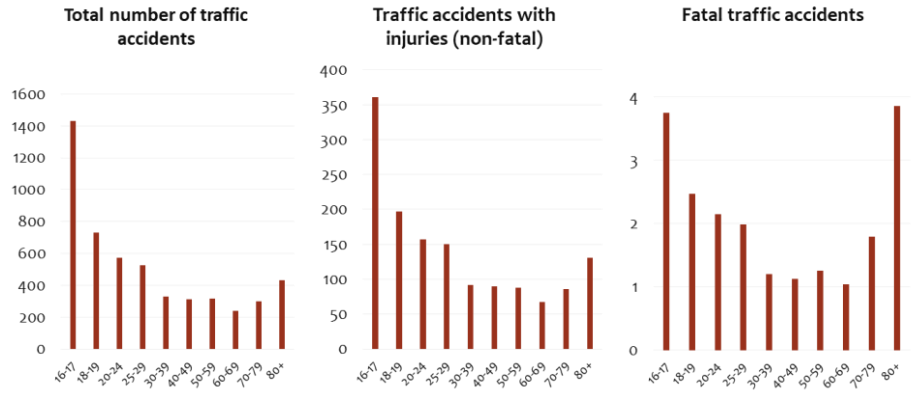
Source: (Statistical Office of the Republic of Serbia, 2022)

In 2020, USA had nearly 48 million licensed drivers who were 65 years of age or older. Elderly drivers are generally more at risk of being injured or killed in a traffic accident compared to younger drivers. This is due, in part, to the fact that elderly are more prone to injury due to age-related changes in their bodies that make them more susceptible to injury. For example, elderly may have weaker bones and less ability to withstand the forces of a collision, which can increase their risk of serious injury or death. Number of traffic accidents in 2014 and 2015 in USA per 100 million citizens in relation to the driver's age is shown in Figure 5. In addition, elderly drivers may be more at risk of being involved in certain types of accidents, such as those involving turns or reversing, due to changes in their vision, reflexes, and other age-related changes that can affect

their driving ability. That being said, it's important to note that not all elderly drivers are equally at risk of being involved in a traffic accident. Factors such as driving experience, overall health, and the presence of any medical conditions that could affect driving ability can all play a role in determining an individual's risk of being involved in a traffic accident (Centers for Disease Control and Prevention, 2022).

The crash death rate for drivers over 75 years old is more than five times the average, and the injury rate is twice as high (European Commission, 2022).

Figure 5. Traffic accidents in 2014 and 2015 in USA per 100 million citizens in relation to the driver's age



Source: (Foundation for Traffic Safety, 2017)

5. Current status of mobility and technologies in automotive industry

According to the Society of Automotive Engineers (SAE) International, there are six levels of vehicle automation, ranging from no automation (Level 0) to full automation (Level 5) (SAE International, 2021).

- Level 0 (No Automation): This level refers to a traditional, manually-operated vehicle with no automation features. The driver is responsible for all aspects of driving, including steering, braking, and acceleration.
- Level 1 (Driver Assistance): At this level, the vehicle is equipped with one or more automated functions, such as electronic stability control or automatic braking, to assist the driver. However, the driver is still responsible for most aspects of driving and must remain attentive at all times.

- Level 2 (Partial Automation): A vehicle at this level has several automated functions that can be used concurrently to assist the driver. For example, a vehicle with adaptive cruise control and lane keep assist could be classified as Level 2. The driver must still be ready to take control of the vehicle at any time.
- Level 3 (Conditional Automation): At this level, the vehicle is capable of performing all driving tasks under certain conditions. The driver must remain attentive and be ready to take control of the vehicle if necessary, but can allow the vehicle to drive itself for short periods of time.
- Level 4 (High Automation): A vehicle at this level is capable of performing all driving tasks under certain conditions and can handle all driving tasks without human intervention. However, the vehicle may still require the driver to take control in certain situations, such as when the automation system encounters an unexpected event.
- Level 5 (Full Automation): A fully automated vehicle is capable of performing all driving tasks under all conditions, without the need for a human driver. The vehicle is self-driving and does not require a human to be present to take control.

It is important to note that the SAE classification is a standardized way of describing the level of automation in a vehicle, but it does not necessarily reflect the capabilities of all vehicles on the market. Some vehicles may have features that go beyond the definitions of the SAE levels, while others may not meet the full requirements of a particular level.

For example, one of the important technologies that is useful for vehicle automation levels 1 to 5 is the recognition of traffic signs on the road. The development of such systems is initially carried out by computer simulations, and before use on regular roads, validation can be carried out on simplified vehicle models under controlled conditions (Mitrović, Popović & Stamenković 2022).

It is difficult to provide an exact percentage of vehicles on the road that have automation beyond Level 3, as the availability and adoption of automated driving technologies varies widely across different regions and markets. In general, however, the majority of vehicles on the road today are classified as Level 0 or Level 1, meaning they have little or no automation. Vehicles with higher levels of automation, such as Level 4 or Level 5, are still in the early stages of development and are not widely available for purchase by consumers.

There are a number of companies and research organizations working to develop fully autonomous vehicles, and some have made significant progress in demonstrating their capabilities. However, it is likely to be several years before fully autonomous vehicles are widely available on the market and in use

by consumers. It is also important to note that the deployment of autonomous vehicles will likely occur gradually over time, rather than all at once, as the technology continues to mature and regulatory frameworks are put in place to govern their use.

Progress in the field of technologies in automotive industry, i.e. manufacturing, is also reflected in the development of exoskeleton systems. An exoskeleton is a wearable device that is worn on the outside of the body. Exoskeletons have the special potential to help women or senior workers by providing support to the muscles and joints, allowing them to perform physical tasks more easily and with less fatigue. This can be especially beneficial for women and senior workers who may be at a disadvantage due to physical limitations or reduced strength and mobility. Different exoskeletons are designed for different purposes and may be more or less popular depending on the specific needs and preferences of the user. However, some exoskeletons that have gained attention in the automotive industry include:

- The EksoVest, developed by Ekso Bionics: This exoskeleton is designed to assist with tasks that require upper body strength and mobility. It is worn like a vest and provides support to the arms, shoulders, and back. The EksoVest is adjustable and can be customized to fit different body sizes and shapes. It is designed to help workers perform tasks such as lifting and carrying heavy objects, and it can be used in a variety of industries, including automotive manufacturing (Ekso Bionics, 2022).
- The IronHand, developed by Bioservo: This exoskeleton is designed to assist with tasks that require hand and arm strength, such as assembling heavy vehicle parts. It is worn like a glove and provides support to the hand, wrist, and arm. The IronHand is designed to be lightweight and easy to wear, and it is powered by a small battery pack (Bioservo Technologies AB, 2022).

6. Conclusions

As the global population ages and life expectancy increases, advanced technologies in the automotive industry are playing a crucial role in addressing the challenges and opportunities presented by population aging. Autonomous vehicles and other forms of assisted mobility can enable elderly to maintain their independence and mobility as they age. In addition, advanced safety features and other technologies can help to reduce the risk of accidents and injuries for elderly. Population aging is a key challenge that Society 5.0 aims to address, through the use of technologies such as assisted living systems and telemedicine to support independent living and the delivery of healthcare to

elderly. By leveraging advanced technologies in the automotive industry and other sectors, Society 5.0 can help to support and empower an aging population.

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