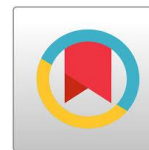


Indonesia Government Policy Strategy to Support Autonomous Vehicles Implementation for Public Transport



Strategi Kebijakan Pemerintah Indonesia dalam Mendukung Penerapan Kendaraan Otonom untuk Transportasi Publik

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ARTICLE INFORMATION	
<p>Keywords <i>Autonomous Vehicles; Public Policy; Public Transportation;</i></p>	<p>ABSTRACT Autonomous vehicles are now a unique and modern new trend in the development of public transport. Its application in various countries such as China, South Korea, Germany, and the United States is interesting to study from policy to implementation. Indonesia also has a great opportunity to develop autonomous vehicles to reach level 3 to 5, considering that the New Capital City (IKN) also has plans to use Integrated Transport System (ITS) and autonomous vehicles as public transport in the future. However, challenges and obstacles such as road facilities, cybersecurity threats, and public indiscipline can be a barrier to the implementation of autonomous vehicles in Indonesia. Therefore, this article aims to take a deeper look into the needs that Indonesia needs to make a policy on autonomous vehicles as public transport in the future.</p>
<p>Kata Kunci <i>Kendaraan Otonom; Kebijakan Pemerintahan; Transportasi Publik;</i></p>	<p>ABSTRAK Kendaraan otonom kini menjadi tren baru yang unik dan modern dalam perkembangan transportasi publik. Penerapannya di berbagai negara seperti China, Korea Selatan, Jerman, dan Amerika Serikat memang menarik untuk dikaji mulai dari kebijakan hingga implementasinya. Indonesia juga memiliki peluang besar untuk mengembangkan kendaraan otonom hingga mencapai level 3 hingga 5, mengingat Ibu Kota Negara Baru (IKN) juga memiliki rencana untuk menggunakan <i>Integrated Transport System (ITS)</i> dan kendaraan otonom sebagai transportasi publik kedepannya. Namun tantangan dan hambatan seperti fasilitas jalan raya, ancaman keamanan siber, dan ketidakdisiplinan masyarakat dapat menjadi penghalang bagi penerapan kendaraan otonom di Indonesia. Oleh karena itu artikel ini bertujuan untuk mengkaji lebih dalam mengenai kebutuhan yang diperlukan Indonesia dalam membuat kebijakan kendaraan otonom sebagai transportasi publik di masa depan.</p>
<p>Article History Send 14th September 2023 Review 24th November 2023 Accepted 27th January 2024</p>	<p>Copyright ©2024 Jurnal Aristo (Social, Politic, Humaniora) This is an open access article under the CC-BY-NC-SA license. Akses artikel terbuka dengan model CC-BY-NC-SA sebagai lisensinya.</p>



Introduction

Autonomous Vehicle (AV) is a new trend in the automotive industry that brings AI or Artificial Intelligence technology into it. With these AI capabilities, AV can drive vehicles without the help of a driver at all (driverless) and can be controlled remotely. AV are not just ordinary unmanned vehicles, but also future vehicles that are needed by everyone and can protect the environment because they are made with the theme ECO Friendly. The types of vehicles classified as AV are generally public vehicles such as cars and buses. Quoted from selectcarleasing.co.uk, of the 30 countries that adopt AV as their public transportation, there are five countries that compete with each other for the best use of AV and the number of driverless car-related patents since 2021 worldwide such as China (11,096), the United States (7,205), Germany (719), South Korea (717), and Japan (633) (Select Car Leasing, 2022). Autonomous vehicles generally run on electric fuel unlike other vehicles that run on fossil fuels. This makes autonomous vehicles more eco friendly because they do not increase gas emissions into the air. In Indonesia, there are not many autonomous vehicles in operation, but one of them can be found in land transportation such as public buses in the BSD City area, South Tangerang (Koraag, 2022).

Although Indonesia is not as fast as other developed countries in implementing autonomous vehicles, the Indonesian government has begun to organise readiness to implement autonomous vehicles as future vehicles in Indonesia. The implementation of modern, autonomous, and eco-friendly public transportation is in line with Indonesia's greencity development programme. Moreover, Indonesia's plan for the New Capital City of the Nusantara (IKN) is based on green mobility that uses advanced transportation or intelligent transport systems (Kurniawan, 2022) Besides being more eco-friendly by utilising electricity as a power source, autonomous vehicles also have the advantage of providing safety and comfort for passengers. With the help of sensors installed in the vehicle body, the mileage can be adjusted according to the settings made remotely.

Not much different from the first study, the second study written by Arief & Putri also highlights the involvement of the Internet of Things (IOT) in each level of autonomous vehicles, which can allow autonomous vehicles to move safely without driver intervention (Widodo & Prasetyaningrum, 2018) The paper written by Stevano & Nico also focuses on the technical capabilities of autonomous vehicles using segmentation techniques. This is done with the help of machine learning, which works so that the autonomous vehicle can detect objects around it or in the environment in which the autonomous vehicle is moving (Darwin & Saputro, 2021).

If the above three studies discuss the technical aspects, the study conducted by Hairudin et al. emphasises the study of the application of autonomous vehicles in Indonesia, especially in Jakarta, which can overcome congestion and reduce existing accidents, provided that the autonomous vehicle first meets the conditions such as road markings and policies provided by the government. According to Hairudin et al. To support this, the government must also consider the environmental impact, one of the things that can be used is the application of artificial intelligence (AI) algorithms to adjust traffic and weather conditions (Hairudin et al., n.d.) The next research paper written by Fred & Agus examines the future of autonomous vehicles in Indonesia by interpreting the theories and predictions of an American physicist named Michio Kaku. This research shows that the development of autonomous vehicles in Indonesia can benefit many aspects, including the use of these vehicles in agriculture. In particular, the ability of autonomous vehicles to distinguish between hard and non-hard objects can help farmers deliver their goods without having to drive a vehicle to a certain point, and can reduce the risk of vehicle accidents due to poorly trained drivers (Soritua Rudiyanto & Sachari, 2020).

Research on the Indonesian Government's Policy Strategy in Supporting the Implementation of Autonomous Vehicles for Public Transportation is very important because the autonomous vehicle phenomenon has great potential to change the transportation landscape in the future. Based on data from Next Move Strategy Consulting, the global market for autonomous vehicles in 2022 reached nearly 17,000 units. The global market for autonomous vehicles will continue to grow until it is projected to reach around 127,000 units by 2030 (Next Move Strategy Consulting, 2023). Indonesia, as a developing country with increasing urbanisation, needs to understand the policy implications to make the most of this opportunity. This research can provide an in-depth understanding of how the implementation of autonomous vehicles can improve transport efficiency, reduce congestion, and provide better accessibility to the public.

Therefore, driving accidents can be minimized (Djadin, 2023) Not only do autonomous vehicles have benefits for the environment and the development of public transport, the development of autonomous vehicles in Indonesia also faces various challenges. The challenges not only come from government policies that regulate the use of autonomous vehicles as public transport, but also road readiness, technology, acceptance of Indonesian society that can hinder the use of autonomous vehicles in Indonesia. This study is also important to ensure that the policies implemented by the Indonesian government are in line with local needs and conditions. Each country has unique challenges and characteristics in

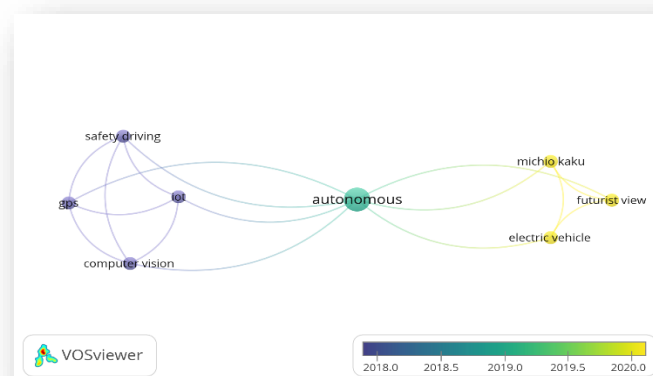
implementing autonomous vehicle technology, such as different infrastructure, varying levels of safety, and different regulations. By conducting this study, the government can design policies that fit the Indonesian context, ensuring that the benefits of autonomous vehicle technology can be felt by as many people as possible, while still paying attention to aspects of safety, privacy, and social impacts that may arise in the future.

Method

The research method used in this article is bibliometrics by using a bibliographic mapping application called VOSviewer. The bibliometric method is a method used to analyse bibliographic data from various literatures such as books, journals and other literatures (Prasetyo, 2021) Meanwhile, according to Nicolaisen, the bibliometric method is a statistical method used by scholars to analyse basic article information such as authors, keywords and references with the aim of providing insight into the development of research topics (Phan Tan, 2022) Before conducting the analysis using VOSviewer, the researchers collected article sources from electronic journals, official government websites, and local and international news websites from 2018 to 2022. A total of 49 articles related to the keyword autonomous vehicle were collected and processed using the bibliographic coupling analysis method.

Bibliographic coupling is a method of analysis in bibliometric methodology. According to Kessler, bibliographic coupling is an article that is jointly cited by two articles/papers published later (Rupadha, 2016) From this understanding, it can be explained that if there are two articles that cite at least one of the same article, then it can be said that the two articles are bibliographically coupled. In practice, this can be seen in the reference list included in both articles (Rupadha, 2016)

Figure 1. VOSviewer Network Visualization



Based on the VOSviewer application mapping, 49 articles related to the topic of autonomous vehicles are mapped into 2 main clusters. The first cluster contains articles that emphasise the discussion of autonomous vehicles in terms of safe driving, GPS, Internet of Things and computer vision. The second cluster contains articles that highlight the discussion of autonomous vehicles in terms of electric vehicles, futurist views, and Michio Kaku's theories and opinions. Furthermore, the researcher developed the keywords mapped in the above two clusters using the bibliographic coupling analysis method to find the main points of novelty regarding autonomous vehicles with Indonesia as the country of study. The researcher took the futurist point of view as the main point underlying the existing studies in this study, taking into account the range of publication periods of articles, which in this point are classified as the latest research, which is in 2020 and needs further development. After obtaining 2 clusters and futurist viewpoints on VOSviewer, researchers found a lack of discussion on the study of government policy strategies, which is actually the most important thing as a supporter of the application of autonomous vehicles in Indonesia in the future at the futurist viewpoint. In order to reach a final conclusion on government policy strategies for autonomous vehicles, the researchers used information from articles in both clusters to see the challenges and barriers to the implementation of autonomous vehicles in Indonesia and to get solutions in terms of government policy strategies.

Literatur Review

Government Policy Strategy

Governments develop policy strategies as part of their role in managing the country and influencing people's lives, it can also called as government policy or public policy (Dye, 2008). These strategies may include concrete measures such as laws, regulations, government programmes, budget allocations, or fiscal policies. The objectives can vary, such as increasing economic growth, reducing unemployment rates, improving the quality of education, increasing access to healthcare, protecting the environment, or maintaining national security. Government policy strategies are usually developed based on problem analysis and research, involve a wide range of stakeholders, and follow an appropriate legislative or regulatory process. The aim is to achieve an appropriate balance between public, economic, social, and environmental interests, and to create positive change in society. Thomas R. Dye in his understanding of government policy strategy suggests that a policy strategy is a plan of government action designed to achieve specific goals. Dye emphasises that this strategy must begin with the establishment of clear and specific objectives, which are what the government

wants to achieve in addressing community problems. The government must choose the right tools or means to achieve these goals, such as policies, programmes or regulations. In addition, government policy strategies also include the plans and directions of action that will be taken to achieve these goals effectively. In Dye's line of thought, government policy strategy is an important tool for addressing social problems and meeting people's needs. It includes the formulation of clear objectives, selection of effective tools, appropriate action planning, as well as the ability to respond to change and conduct continuous.

Apart from Dye, William N. Dunn also argues that policy strategy is an important activity before making a policy. These activities are in the policy-making process where problem research is carried out to determine the direction of the policy to be taken (Dunn, 2008) Not only Dunn, Anderson also explained that to form a policy that is in accordance with the needs of the community, at least there are several steps that must be taken, namely the first to identify issues or problems that need to be addressed by policy, and define the goals and objectives to be achieved. Second, policy analysis which involves collecting relevant data and information, as well as evaluating possible policy options. The third stage is decision-making, where the most appropriate policy option is selected based on the results of the analysis. Finally, policy implementation and evaluation are conducted, including implementation planning, monitoring, and adjustment if necessary. Anderson emphasises the importance of collaboration and communication between stakeholders in the entire policy-making process (Dr. Joko Widodo, 2021).

Leong C & Howlett M. in their article entitled Policy Learning, Policy Failure, and the Mitigation of Policy Risks: Re-Thinking the Lessons of Policy Success and Failure explains that the failure of a policy strategy can come from the government's impartiality as a policy-making actor towards the interests of the people and also the lack of learning how to deliver policies and programmes properly (Leong & Howlett, 2021). Leong & Howlett also assume that studying problems before policy making should be evidence-based in order to better design policy content and improve policy outcomes. In the article, Leong & Howlett recognise that pre-policy learning may come from different types of government activities, therefore anticipating policy failures should take into account not only the political, process, and problem-oriented nature of the problems, but also that they may come from different points in the policy process. Which means that some failures in policy strategy occur directly in the process of formulating the problem agenda, while other failures arise later due to problems encountered in formulation or decision-making as well as during the implementation and evaluation process (Leong & Howlett, 2021) Subhan H. (2019) in his article published in

Jurnal Ilmu Sosial dan Ilmu Politik UIN Sunan Gunung Djati believes that evidence based can solve problems systematically because it is supported by data, risk analysis and proactive response and identification (Subhan, 2019).

Autonomous Vehicle Concept

An autonomous vehicle is a vehicle that is capable of operating without the presence of a human driver (driverless). It is equipped with various technologies such as sensors, cameras, radars, and software that enable it to recognise its surroundings, make decisions, and control the vehicle independently. The way autonomous vehicles drive is by using Light Detection and Ranging (LIDAR) and Radio Detection and Ranging (RADAR) technologies (Cadence, n.d.) They are two types of sensors that assist autonomous vehicles in mapping and detecting objects around the vehicle. This autonomous technology aims to reduce dependence on human drivers, improve road safety, reduce congestion, and provide comfort and efficiency in mobility (Company, 2023). Autonomous vehicles can be cars, trucks, buses, or even drones that can operate without human intervention (Kearns et al., 2016). There are several levels of vehicle autonomy defined by SAE International (Society of Automotive Engineers), namely:

- Level 0: No autonomy, all functions are controlled by the human driver.
- Level 1: Driver assistance system, the vehicle has features such as cruise control that can control speed, but the driver still has to actively control the vehicle.
- Level 2: Partial autonomy, the vehicle has the ability to control speed, acceleration and braking, but the driver must still monitor road conditions and be ready to take over control if needed.
- Level 3: Limited autonomy, the vehicle can control most operational aspects, but the driver must be ready to take over control with certain warnings from the system.
- Level 4: High autonomy, the vehicle is capable of operating itself under predefined conditions without driver involvement. However, the vehicle may still require the driver to take over control in some situations.
- Level 5: Full autonomy, the vehicle is fully autonomous and does not require the presence of a human driver under any conditions.

Currently, the presence of autonomous vehicles in Indonesia is still in the early stages of development. However, several companies and institutions have conducted autonomous vehicle trials in several cities in Indonesia. Here are some examples of autonomous vehicles that have been tested in Indonesia:

- a. Esemka-BIMA autonomous car: Esemka is an Indonesian car manufacturer that has developed an autonomous car called BIMA (Bengawan Intelligent Mobility Assistant). The car is equipped with self-driving technology and has been tested on several roads in East Jawa (W. D. Putri, 2023).
- b. Gojek autonomous car: Gojek, one of the largest online transport service providers in Indonesia, is also testing autonomous vehicles. In 2020, Gojek announced its plan to test autonomous cars in certain areas of Indonesia.

Challenges and Barriers to The Implementation of Autonomous Vehicles in Indonesia

As autonomous vehicles are a new innovation in transport technology, the implementation in other countries may be different from Indonesia. Countries that have implemented autonomous vehicles earlier also have their own challenges and barriers in terms of regulations, technology and facilities. Here are three challenges and barriers to the implementation of autonomous vehicles in Indonesia:

Indonesian government regulation of autonomous vehicles in Indonesia

There is no specific law regulating autonomous vehicles in Indonesia. However, there are several laws issued by the government to address the development of autonomous vehicles. Minister of Transportation Regulation No. 15 of 2022 on the Conversion of Motor Vehicles Other than Motorcycles with Fuel Motor Driver into Battery-Based Electric Motor Vehicles, this regulation regulates technical and safety requirements for motor vehicles with advanced features, including autonomous vehicles (BPK, 2022). In addition, Minister of Transportation Regulation No. 44 of 2020 on Physical Type Testing of Motor Vehicles with Electric Motor Driver, this regulation contains technical requirements, testing procedures and obligations to be fulfilled by parties conducting tests (BPK, 2020).

There are certainly shortcomings in the above regulations, particularly in terms of ensuring the safety of other road users in the event of technical and system failures in the LIDAR and radar of autonomous vehicles, how the owner of an autonomous vehicle can take over the vehicle in an emergency, what the safety standards are for autonomous operation, and which areas of related agencies such as the police and the Ministry of Transportation have been designated to test autonomous vehicles with facilities specifically for autonomous vehicles. In addition, there are no regulations in Indonesia that address the responsibilities of autonomous vehicle manufacturers and vehicle owners, as well as insurance for drivers or owners of autonomous vehicles.

Consider the regulations in China and the United States regarding autonomous vehicles. In China, there is a regulation called the Standards for Intelligent and Connected Vehicles, which includes safety standards for autonomous vehicles, such as vehicle-to-vehicle communication, sensor systems and autonomous operation. In addition, there are also special areas in China for conducting permitted autonomous vehicle trials, such as Beijing City and Shanghai City (China Daily, 2022; Xinhua, 2022b) These areas already have autonomous vehicle development and testing facilities, taking into account the regulatory and safety aspects there.

Meanwhile, in The United States, the law that regulates autonomous vehicles is the Self-Driving Vehicle Safety Act (NHTSA, n.d.-a). More comprehensive than the regulations implemented in China, this regulation includes the definition of autonomous vehicles, certification and compliance issued by the National Highway Traffic Safety Administration (NHTSA), and the protection of privacy and data security. The law aims to create a clear regulatory framework for the development and use of autonomous vehicles in the United States (NHTSA, 2016). Given that China and The United States are focusing on legislation to regulate the licensing and reporting requirements of autonomous vehicles, this is a challenge for Indonesia, where accidents or damage may occur due to autonomous vehicles, while Indonesia does not yet have the regulatory capacity to ensure the safety of autonomous vehicle drivers, vehicle manufacturers and other road users.

Roadway Standardisation

Autonomous vehicles can drive without the help of a human driver because they use LIDAR and RADAR technology to detect objects around them, including the condition of the roads they are driving on. This requires roads with adequate infrastructure conditions, ranging from flat and pothole-free road quality to complete road markings, working street lights, and so on. Based on the Indonesian Land Transport Statistics 2021 by the Central Statistics Agency (BPS), the length of Indonesian roads outside toll roads reached 546,116 kilometres (Kompas.com, n.d.). Of this amount, if it is detailed from the road condition, it is found that 42.6% or 232,644 kilometres of roads in Indonesia are in good condition. Then, 25.49% or about 139,174 kilometres are in moderate condition, 16.01% or 87,454 kilometres are in damaged condition, and 15.9% or about 86,844 kilometres are in severely damaged condition (BPS RI, 2022). If you look at the percentage value of roads with good and moderate condition only about 42.6% and 25.49%, this is what causes the use of autonomous vehicles in Indonesia

to be hindered, because in addition to the autonomous steering system, it can also endanger the safety of many people.

In addition, autonomous vehicles are designed to be eco-friendly by not using fossil fuels, which cause air pollution, but by using electricity to charge the batteries. For charging, special charging stations such as electric pom are needed, which support fast charging like refuelling other vehicles (Navya, n.d.). By the end of 2022, the number of vehicle electric pom managed by PT PLN is only 570 units of PLN Electric Pom from all regions of Indonesia (PLN.CO.ID, 2022). While in April 2022, it was recorded that fuel oil stations are still superior with 6,729 units throughout Indonesia (A. M. H. Putri, 2022). This condition can also hinder the development of autonomous vehicles in Indonesia, it needs adequate electric charging facilities to ensure the use of autonomous vehicles.

Autonomous vehicles also need an excellent internet network, so the uneven internet network in Indonesia can be an obstacle to the development of autonomous vehicles. The average autonomous vehicle processes an internet network of 4,000 gigabytes (GB), which requires sophisticated information technology (Priyantoro, 2022).

Public Acceptance

There has never been a survey that shows Indonesian public's satisfaction with autonomous vehicles. Various automotive companies developing autonomous vehicles have not confirmed when autonomous vehicles can be widely used by Indonesians. However, the author quotes the statement of one of the private car company officials on the *hypeabis.id* page. A marketing director of PT Toyota Astra Motor named Anton Jimmy Suwandy said that a major obstacle that could be a challenge to introduce autonomous vehicles such as autonomous cars is the infrastructure that is not ready in Indonesia (Venda, 2023) Nevertheless, Toyota, as a private company, is still trying to develop advanced capabilities in vehicles that almost lead to autonomous vehicle technology, for example by installing Toyota Safety Sense (TSS) technology in several cars circulating in Indonesia, this technology allows cars to have capabilities like other autonomous vehicles, even though they still use drivers. These capabilities include monitoring the distance to other vehicles and reading the state of the car to keep it in the lane (Venda, 2023).

Besides Toyota, various private automotive companies in Indonesia are also supporting the development of autonomous vehicles in Indonesia, such as Sinar Mas Land in cooperation with Mitsubishi Corporation, PT.PLN, Telkomsel, PT.Volta and so on. The lack of responses and surveys from the public on autonomous vehicles until 2023 has not deterred the

government and the private sector from developing AI technology in vehicles. At least academics are also actively highlighting the government's desire to implement advanced vehicles, such as autonomous vehicles, in Indonesia in the future. The government also supports and invites academics to participate in the innovation and development of autonomous vehicles in Indonesia, such as the Minister of Transportation Budi Karya Sumadi, who in 2020 expressed his support and hope for universities to conduct research and development of autonomous vehicles. This support was conveyed in a webinar entitled *How Will Autonomous Vehicles Transform Our New Capital*, and the Minister of Transportation also expressed predictions for the next 5 to 10 years that Indonesia's autonomous vehicle automotive industry will be able to outperform today's conventional cars (Maskur, 2020).

In addition to government support for universities, several universities in Indonesia are also developing research related to autonomous vehicles, such as the Gadjah Mada University (UGM) team that won the Shell Eco Marathon 2023 autonomous car programming championship, Institut Teknologi Sepuluh Nopember (ITS) in collaboration with Nokia and Indosat Ooredoo in developing the ITS 5G Autonomous Concept Car (i-Car) or an unmanned car with a 5G internet network, and research by the Instrumentation and Control Expertise Group (KK) Faculty of Industrial Technology, Institut Teknologi Bandung (ITB) with research related to autonomous cars for trajectory tracking using a machine learning approach (Herdiana, 2021; Widiyana, 2021; Zubaidah, 2023).

Result and Discussion

Government policy strategy to support the implementation of autonomous vehicles in Indonesia

Currently, Indonesia does not have a specific policy on autonomous vehicles. The policy on autonomous vehicles is only limited to the technical and safety requirements of advanced vehicles such as electric vehicles (BPK, 2020, 2022). For this reason, it is necessary to create a specific policy for autonomous vehicles, considering that the future transformation plan for eco-friendly and advanced vehicles also opens up great opportunities for the autonomous vehicle market in Indonesia. Although many large countries are competing in the development of autonomous vehicles, such as Germany, China, the United States, Japan and South Korea, the author will provide more references on autonomous policies in South Korea. This is because South Korea has gradually designed and passed the necessary policies to support the use of autonomous vehicles and the fulfilment of their facilities in detail (MOLIT,

2021). The following are some things that can be policy recommendations for the Indonesian government to formulate a special autonomous vehicle policy:

Conduct Road Standardisation

The policy on road standardisation for autonomous vehicles should include issues related to communication infrastructure, road markings, traffic signals, sensor technology and infrastructure marking, access to up-to-date map data, intelligent traffic management and infrastructure quality control. Some of them that can support the performance of autonomous vehicles on the highway can be controlled and prioritise the safety of users, both autonomous vehicles themselves and other road users. For now, Indonesia already has regulations related to road standardisation or road infrastructure obligations contained in Article 25 of Law No. 22 of 2009 on Road Traffic and Transportation (BPK, 2021) This Article requires that every road must have traffic signs, road markings, traffic signalling devices, traffic lights, and road monitoring and safety devices. However, the law is still not enough to facilitate the operation of autonomous vehicles on the road. These facilities mean that motorways must have additional equipment such as internet networks, sensor technology and access to map data such as up-to-date GPS.

For example, South Korea has an intelligent transport law that has been adapted by the Ministry of Land, Infrastructure and Transport (MOLIT) into the National Integrated Transport System Efficiency Act. With this law, South Korea created the Intelligent Transport System (ITS) Master Plan 2030, which includes the development and deployment of intelligent transport systems for each transport sector, including automobiles, roads, railways, aviation and shipping (MOLIT, 2021). The plan also includes several things needed to support fully autonomous vehicles operating in South Korea, such as intelligent transport system information collection and intelligent transport facilities. The facilities in question are mentioned by increasing the accuracy of information collected and using advanced technologies such as artificial intelligence, building the Internet of Things (IoT) and C-ITS or communication infrastructure that will be built on major roads (highways, etc.), as well as authentication is established to support the smooth operation of autonomous vehicles. In addition, South Korea has also equipped its highway facilities with integrated safety management systems, such as road condition management systems, which can provide risk information to drivers by expanding CCTV monitoring systems that can detect unexpected situations, such as real-time detection of road surface conditions (e.g. falling rocks or other obstacles in front of the vehicle). This can enhance road safety (MOLIT, 2021).

Safety Standards for Each Level of Autonomous Vehicles

Safety standards for each level of autonomous vehicles are the most fundamental things that need to be included in autonomous vehicle policy. Autonomous vehicles have several levels with different levels of driving automation. A global association called SAE or commonly called The Society of Automotive Engineers classifies the level of autonomous vehicles into 6 parts, namely Level 0 to Level 5. The classification created by SAE has become the most cited reference source by the autonomous vehicle industry (SAE, 2021). With this classification, each autonomous vehicle has differences in terms of human requirements, vehicle features and examples that can affect the level of autonomous vehicle capability in automatic driving (Krishnakumar, 2022). Since level 1 and level 5 autonomous vehicles have different levels of safety and technical failures, some countries have set autonomous vehicle safety standards in their policies. This is done to regulate autonomous vehicle lanes on prepared roads, maximum speed, and to reflect autonomous vehicle safety standards that can prevent accidents. On the other hand, through these safety standards, countries can also hear and reflect the interests of autonomous vehicle manufacturers at home and abroad (MOLIT, 2020).

The non-profit organisation UL Standards & Engagement also published several autonomous vehicle safety standards, which have been adopted by many autonomous vehicle industries (UL Solutions, n.d.). Some of these safety standards consist of 4 standards, including ANSI/UL 4600, the standard for safety for the evaluation of autonomous products, which contains safety principles and procedures for the evaluation of fully autonomous vehicles, vehicles that do not require human driver supervision, this standard provides the flexibility needed to ensure and support the rapid development of autonomous vehicle technology. Secondly, the standard ISO 26262: Road vehicles - Functional safety, which is an automotive standard that applies to electrical systems (E/E) in autonomous vehicles, ISO 26262 also emphasises functional safety management in the event of system failure due to malfunctions or faults in the E/E system, in addition, this standard is also an important factor in promoting the safety of autonomous vehicles.

Thirdly, the ISO 21488 standard: Road vehicles - Safety of intended functionality (SOTIF). This standard addresses unintended system behaviour in the absence of faults in the ISO 26262 standard. This standard applies to advanced vehicles and emergency intervention systems. Although this standard complements the deficiencies of ISO 26262, it is separate and distinct from ISO 26262 and is used as a consideration for each level of autonomous vehicles as defined by SAE International. Fourth, the standard ISO/SAE 21434: Automotive Cybersecurity. This standard addresses mandatory requirements for managing cybersecurity

risks in vehicles, including their components. ISO 21434 covers the lifecycle of the product from concept, design, development, production to operation, maintenance and decommissioning and is critical to reducing vulnerability to cyber-attacks (UL Solutions, n.d.). With autonomous vehicle safety standards in place, there is a deep understanding and alignment with industry safety standards, which is necessary to help innovators manage the complexities of risk management and build trust in autonomous technology.

Public Education

It is important for the public to be aware of the rules of the road. This awareness is important to prevent accidents and ensure the safety of all road users. In 2022, the Indonesian Traffic Corps (Korlantas RI) stated that the number of traffic accidents across Indonesia from January to 13 September 2022 reached 94,617 cases. Meanwhile, in the case of traffic violations, data from the National Criminal Information Center (Pusiknas) of the Indonesian National Police (Polri) stated that 2.12 million traffic violations occurred in Indonesia in 2021. This number consists of 879,962 serious violations, 269,996 medium violations and 965,286 minor violations (Sadya, 2022).

Driving discipline is an important issue that the government must continue to improve for its citizens. Although autonomous vehicles can be remotely controlled by humans, autonomous vehicles still rely on sensors and radar to drive without crashing into surrounding objects and to detect traffic signs in front of them, so public indiscipline on the road can lead to accidents between motorists and autonomous vehicles. In addition to public discipline, the public also needs to understand the mechanics of using autonomous vehicles as public vehicles. Drivers can also be certified and trained by relevant institutions, such as the Ministry of Transport or the National Police, before applying for a licence. Furthermore, autonomous vehicles are also equipped with communication links or vehicle-to-vehicle links so that the development of autonomous vehicles in Indonesia can continue to increase (NHTSA, n.d.-b).

The country can also work with companies that can provide training and certification for autonomous vehicles, such as the international company TUV SUD. Companies like TUV SUD are already licensed by the government in several countries and their certifications are recognised by those countries (TUV SUD, n.d.-a). For example, some of TUV SUD's certifications are recognised by the North American Nationally Recognised Testing Laboratory (NRTL), by OSHA (The Occupational Safety and Health Administration) in the United States, and as a product certification body by SCC (Standards Council of Canada) in Canada. Moreover, TUV SUD is also involved in the development of autonomous vehicle testing, such

as the PEGASUS project with the German government, CETRAN with the Singapore government, and the openGENESIS project with the German Artificial Intelligence Research Centre. (TUV SUD, n.d.-b). Some of the things in autonomous vehicle testing and certification services that can be carried out by TUV SUD companies include system and effectiveness assessments, combined testing approaches such as simulation and test frameworks, cybersecurity measures, and homologation services for the operation of automated vehicles on public roads (TUV SUD, n.d.-a).

Cybersecurity for Vehicle Owners and Users (Data Exchange)

This Cybersecurity is the most important part to be included in the autonomous vehicle policy in Indonesia. There is data storage related to the owner, technical supervision and manufacturer of autonomous vehicles in the black box in the vehicle body. Not only storage, but also data exchange such as geolocation, time of use, alternative driving manoeuvres, environmental conditions, and speed and communication (Kriebitz et al., 2022). Some of them can be overcome by placing the authority for autonomous vehicle data exchange with an agency such as the Indonesian National Police, the Ministry of Transport, or a dedicated agency that regulates motor vehicles, as Germany has done by establishing the Kraftfahrt-Bundesamt. With the authority to regulate the exchange of autonomous vehicle data, interested parties in Germany can provide useful data for accident analysis and research. In addition, data stored in autonomous vehicles can be protected by an authorised authority (Kriebitz et al., 2022). In addition, there are autonomous vehicle standards that can be used as a consideration for autonomous vehicle policy. This standard, published by UL Standards & Engagement, has been adopted by many autonomous vehicle industries and is commonly referred to as the ISO/SAE 21434: Automotive cybersecurity standard. As autonomous vehicles have advanced communication capabilities that can be subject to cyber-attacks and data theft activities, ISO 21434 is designed to provide strong protection and ensure cybersecurity in autonomous vehicles. The standard also provides a framework for authorised organisations to assess, manage and mitigate the risk of cyber-attacks on vehicles (DiGiuseppe, n.d.).

Some of the existing applications of ISO 21434 in autonomous vehicles include identifying assets and potential damage due to breaches of security features, identifying and analysing possible attack threats and vulnerabilities, providing risk levels based on damage scenarios and the likelihood of successful cyber-attacks, taking precautions up to acceptable risks, and documenting key steps and results of the risk assessment process such as asset lists, damage scenarios and damage reports (DiGiuseppe, n.d.).

Special Areas for Autonomous Vehicle Development and Testing

In order to support the commercialisation of autonomous vehicles, the government needs to facilitate large-scale testing, one of which is to provide dedicated areas for autonomous vehicle testing. Some countries that already have regulations and implementations in place to open autonomous vehicle testing grounds include China, Germany, the United States and South Korea. Firstly, China has opened up to 27 provinces and cities in 2021 by issuing regulations on driverless vehicles, establishing 16 autonomous driving demonstration zones, and opening more than 3,500 km of test roads (Huaxia, 2021). China also complements autonomous vehicle trials by releasing standards for scenario-based autonomous vehicle testing under the name *2022 Road Vehicles- Test Scenarios for Automated Driving Systems- Vocabulary* (Xinhua, 2022a).

Second, Germany. Through Deputy Minister President Thomas Strobl and Minister of Transport Winfried Hermann, opened an autonomous vehicle test area in the Baden-Württemberg region in 2018. The Baden-Württemberg region serves as a safe vehicle test area by providing a laboratory that covers the entire process of autonomous driving, parking, and product delivery to consumers, including autonomous buses, autonomous cars, autonomous delivery service vehicles, and commercial vehicles such as street cleaning and delivery service vehicles. Researchers and developers also stressed the importance of privacy: In order to create acceptance for such forward-looking initiatives, it is important to ensure the protection of personal data (Oberdorf, 2023).

Third, the United States. Nevada was the first state to allow the operation of autonomous vehicles in 2011. Since then, 21 other states - Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Louisiana, Michigan, New York, North Carolina, North Dakota, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Vermont and Washington D.C. - have passed autonomous vehicle legislation. Some state governors have also issued executive orders for the testing and operation of autonomous vehicles in their territories, such as Wisconsin Governor Scott Walker in 2017, Washington Governor Jay Inslee in 2017, Ohio Governor John Kasich in 2018, Minnesota Governor Mark Dayton in 2018, Massachusetts Governor Charlie Baker in 2016, Maine Governor Paul LePage in 2018, Illinois Governor Bruce Rauner in 2018, Idaho Governor C. L. "Butch" Otter in 2018, Hawaii Governor David Ige in 2017, Delaware Governor John Carney in 2017 and Arizona Governor Doug Carey in 2015 (NCSL, 2020). Finally, The Republic of South Korea. South Korea has special zones for testing autonomous vehicles. The existing zones are in the following locations such as Gangnam area in Seoul, Sangam-dong/DMC area in Seoul,

Yeouido area in Seoul, Mogok area in Seoul, Pangyo Citi Zone, Gwangju City Zone, K-City. There are further discussions to add the Cheonggyecheon area in Seoul to the pilot zone in late 2022 or early 2023 and to add Sejong City as well (Leddar.tech, 2022).

Meanwhile, Indonesia has a great opportunity to position The New Capital City Nusantara (IKN) as a pilot region for large-scale testing and operation of autonomous vehicles in Indonesia. IKN can become a transport technology centre that will influence other regions and provinces to emulate the implementation of autonomous vehicles in Indonesia. Quoting from the press statement of IKN Authority Head Bambang Susantono during the inauguration of the first autonomous vehicle trial (autonomous bus) in Q-Big BSD City, he stated that autonomous vehicles will be an important main means of public transport in IKN. Then, the IKN Authority is also developing the Nusantara Master Plan, which includes the use of intelligent transport system (ITS) by applying the Internet of Things (IoT) and the use of big data and artificial intelligence (AI) (Saputra, 2022).

Conclusion

The development of autonomous vehicles will be a continuing trend as many countries have already reached level 3 of autonomous vehicle deployment. Indonesia also has a great opportunity to use autonomous vehicles for public transport. Autonomous vehicles have many advantages for the environment as they do not use fossil fuels, but instead use electricity with batteries as their power source. However, the implementation of autonomous vehicles in Indonesia has its own challenges and obstacles, such as the lack of specific government regulations for autonomous vehicles operating in Indonesia, road standardisation that does not meet the needs of autonomous vehicles, and public acceptance that has not been widely achieved due to the lack of massive education by the government. The lack of widespread implementation of autonomous vehicles is not stopping the development of autonomous vehicles in Indonesia.

Autonomous buses in BSD, Esemka cars, and i-Cars have shown that Indonesia is also trying to modernise transport with autonomous vehicle technology. For this reason, several things that already exist in the policies of many countries that have a high level of autonomous vehicle technology can be used as a source of reference for policy making in Indonesia. Of course, it needs to be adapted to the needs and conditions in Indonesia. Some things that can be recommendations for the Indonesian government's policy strategy in implementing autonomous vehicles as public transport include standardising roads by facilitating autonomous vehicles with sensor technology, 5G internet networks, CCTV, advanced GPS technology, and

additional electric ports to support vehicle charging. Creating safety and security standards for each level of autonomous vehicles; the capabilities of level 3 autonomous vehicles are different from those of level 4 or 5 autonomous vehicles, so safety standards need to be used as a basis for autonomous vehicle policy.

Moreover, the public must be educated to own and operate autonomous vehicles with proven capabilities so as not to endanger other road users. Therefore, the government can educate the public by providing training and requiring certification before obtaining a licence to operate autonomous vehicles. The government can also work with international training services to certify autonomous vehicles, such as TUV SUD. Then, the most important thing that needs to be included in the autonomous vehicle policy is cybersecurity for vehicle owners and users, considering that autonomous vehicles not only store and access information in their memory, but can also exchange data with other vehicles. In addition, the government can establish a special agency to oversee the exchange of data in autonomous vehicles as a provider of accident assessment and to protect existing data. Finally, the government must provide a dedicated area for the development and testing of autonomous vehicles. This will support the commercialisation of vehicles and large-scale testing. This area is already equipped with all the facilities needed to test the feasibility of autonomous vehicles.

This study provides a comprehensive exploration of the initiatives and strategies undertaken by the Indonesian government to facilitate the integration of autonomous vehicles into the public transport system. However, for further study, it is recommended to go more in-depth on certain aspects that may not have been fully covered in this study. For example, focus on analysing the economic and social impacts in more detail of the use of autonomous vehicles in the context of public transport. Research could examine the impact on employment, changes in people's travel patterns, as well as infrastructure changes that may be required. In addition, research could consider the long-term perspective of using the technology, including the legal and ethical implications associated with autonomous vehicles. In addition, research could investigate the public's views and expectations of autonomous vehicles, as well as the factors that influence the acceptance and adoption of this technology. By considering multi-stakeholder viewpoints, future research can provide a more holistic view of the dynamics involved in facing the challenges and driving the successful implementation of autonomous vehicles in Indonesia.

Acknowledgments

We would like to express our deepest gratitude and appreciation to the Public Administration Department and academics at the Faculty of Administrative Sciences, Universitas Islam Malang, who helped with ideas and moral support to make this article possible. We hope that this article can provide new insights, especially for policy makers in formulating the right policies for the implementation of autonomous vehicles in Indonesia.

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