Comparative Study on Autonomous Vehicle Operation Status in South Korea and China

- Focusing on Xiong'an New District in China and Sejong City in South Korea -

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Abstract

Today, many countries around the world recognize the development of autonomous vehicles as a national growth engine, support technology development through various projects, and promote it as national policy. China and Korea are representative countries that are strongly promoting autonomous vehicle policies. The Chinese government's policy direction for self-driving cars focuses on support for fostering new industries. Korea has established mid- to long-term goals and plans to foster the future mobility industry as a key growth engine and is promoting these as a national task.

Recently, China and Korea have established national pilot areas to test autonomous vehicle operation and are actively pursuing policies. We aim to compare and analyze the operation status of self-driving cars in China's Xiong'an New Area and South Korea's Sejong City and derive policy implications regarding self-driving cars, which are emerging as a key industry of the future.

According to the analysis results, it was found that China's Xiong'an New District is ahead of Korea's Sejong City in terms of leader leadership. As a result, autonomous driving is being operated at the government-wide and national level in Xiong'an New Area. In terms of the driving force, in the case of Xiongan New Area, the policy is being promoted by companies centered on Baidu, and in the case of Sejong City, the policy is being promoted by the local government. As a result, it is estimated that Xiongan New Area will be able to reach commercialization before Sejong City.

In the final policy proposal, it was proposed to break away from the existing government-led method and switch to a collaboration with the private sector and a private-led method.

Keywords: *Autonomous Vehicle, Smart Mobility, Smart City, Xiong'an New District, Sejong City, Information & Communication Technology, Digital Transformation,*

I. Introduction

An autonomous vehicle is a vehicle that can operate on its own without driver or passenger intervention. In other words, autonomous driving is a car that integrates cutting-edge technologies such as ICT and sensors into the car to recognize the surrounding environment, judge risks, and plan the driving route to enable safe driving without driver or passenger intervention. The concept of autonomous driving has been around since the 1960s, and rudimentary research began in the late 1970s. In the beginning, it was at the level of not crossing the center line or lanes at the test driving range without any obstacles, but in the 1990s, as the field of computer judgment technology developed greatly, the field of autonomous driving involving obstacles began to be studied in earnest.

Then, entering the 2000s, various companies actively invested in technological development in this field, achieving remarkable progress. Therefore, starting in the 2010s, laws and regulations were prepared for the commercialization of autonomous vehicles. In particular, along with the world's leading automobile companies, car sharing companies such as Uber, as well as ICT companies such as Google, Apple, and Amazon have entered the field of autonomous driving.

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CES (Consumer Electronics Show) 2023, one of the world's top three IT exhibitions and an important event in understanding the latest technology trends, was held from January 5 to January 8, 2023 at the Las Vegas Convention Center in the United States. 'Metaverse' appeared as a new theme at CES 2023, and the five major themes are 1) Web 3.0/Metaverse, 2) Mobility, 3) Digital Healthcare, 4) Sustainability, and 5) Human Security. Among these, mobility is emerging as the most important in future industries. In other words, all companies around the world are investing in new technologies related to future mobility, focusing on autonomous driving, electric vehicles, connected cars, and vehicle software. [1]

As such, today, the world's leading automobile companies are risking their lives on the development of self-driving cars, and many big tech companies are all progressing the development of self-driving cars. KPMG, a global consulting firm, predicted that the autonomous vehicle market, which was worth $7.1 billion in 2020, will grow to $1.1204 trillion in 2035 [1].

Therefore, many automobile companies and ICT companies are currently accelerating development by obtaining temporary permits to drive on public roads and test driving self-driving cars. This type of autonomous driving was first tested in the United States, Germany, and Japan. The United States is currently the most advanced country in testing autonomous vehicles. In the United States, testing of self-driving cars has been conducted at the state level for a long time, and self-driving taxis have recently been commercialized and operated.

However, China and South Korea are representative countries where such self-driving car experiments have recently been attempted at the national level. At the national level, China and South Korea recognize the autonomous vehicle field as a growth engine for national development, and the government is taking the lead in promoting policies.

Therefore, in this paper, we aim to compare and analyze the operation status of self-driving cars in China's Xiong'an New Area and South Korea's Sejong City and derive policy implications regarding self-driving cars, which are emerging as a key industry of the future.

This paper is organized as follows. Section 2 discusses relevant literature on the concept of autonomous vehicle. Section 3 identifies AV Policy and Utilization Status in China and Korea, while an empirical results of AV using Xiongan New Area and Seoul City as case studies Section 4. Section 5 concludes with a theoretically grounded elaboration of these policy implications as they emerge from our empirical results and states the Policy Advices implications of this study.

II. The advent and Use of Autonomous Vehicle

Google has been developing self-driving technology since 2008, and was the first in the world to unveil its self-driving car development program in 2010. In 2014, the company introduced a prototype 'Google Car' without a steering wheel or brakes. In 2016, the self-driving division was spun off into WAYMO, and in 2018, the world's first self-driving taxi service, 'Waymo One', was commercialized.

However, today, the company with the most advanced technology in the field of autonomous driving is Tesla. In 2015, Tesla launched the Model S equipped with the world's first semi-autonomous driving system, Autopilot. Autopilot includes an 'Autosteer' function that maintains driving speed and lane according to the speed of surrounding cars, and an 'Auto Lane Changer' function that automatically changes lanes when the turn signal is turned on.

Recently, all of the world's leading automobile companies possess self-driving car technology. In particular, in 2021, Mercedes-Benz obtained international certification for 'Drive Pilot', the world's first level 3 conditional autonomous driving system, and installed it on the 'S-Class' and the electric vehicle 'EQS' in 2022. 'Drive Pilot' is currently being used on certain sections of German highways where conditional autonomous driving is permitted. Mercedes-Benz went one step further and introduced the world's first level 4 unmanned parking technology through 'Intelligent Park Pilot', an intelligent automatic valet parking technology.

Autonomous driving technology can be classified from levels 0 to 5 depending on the level of automation, and levels from level 3 are considered autonomous vehicles. The details of the level and technology of autonomous driving are summarized as follows.

[1] At the 2023 CES, Honda Sony Mobility, a joint venture between Japan's Sony and Honda, unveiled 'Apila', the first electric concept car with level 3 autonomous driving capabilities.

2.1. Level of Driving Automation

Autonomous vehicles, also called self-driving cars or autonomous cars, refer to cars in which some or all of the driving functions are performed unmanned. Autonomous vehicles are 'autonomous' because they use sensors to understand their operating environment and make driving decisions based on that data without human driver intervention.

Although self-driving cars are sometimes thought of as simply cars driving themselves, the Society of Automotive Engineers (SAE) believes that autonomous vehicles can range from low-level assistance for a human driver to full autonomous control of the vehicle. Driving skills were classified into 6 levels as shown below (Figure 1) [2].

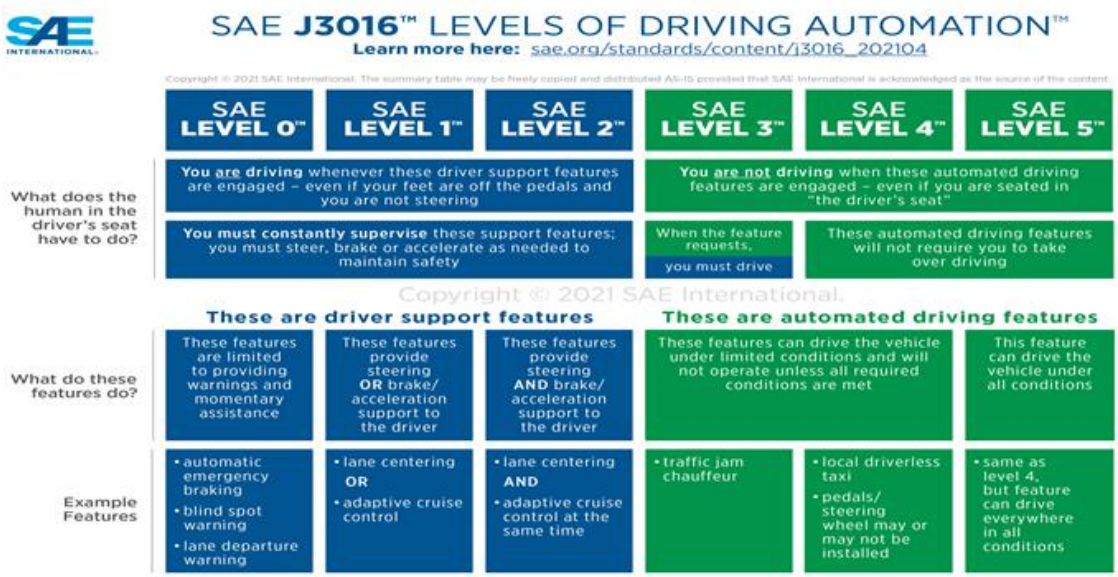

Figure 1. SAE Automation Levels

This level describes vehicle driving automation systems that perform part or all of the dynamic driving task (DDT) on a sustained basis. It provides a taxonomy with detailed definitions for six levels of driving automation, ranging from no driving automation (Level 0) to full driving automation (Level 5), in the context of vehicles and their operation on roadways:

Level 0: No Driving Automation
Level 1: Driver Assistance
Level 2: Partial Driving Automation
Level 3: Conditional Driving Automation
Level 4: High Driving Automation
Level 5: Full Driving Automation

These level definitions, along with additional supporting terms and definitions provided herein, can be used to describe the full range of driving automation features equipped on vehicles in a functionally consistent and coherent manner. "On-road" refers to publicly accessible roadways (including parking areas and private campuses that permit public access) that collectively serve all road users, including cyclists, pedestrians, and users of vehicles with and without driving automation features.

The technology level of self-driving cars is currently Level 3 Conditional Driving Automation. Level 3 is the Limited Automation stage, where automatic parking, driver fatigue measurement, braking and lane keeping are being commercialized. Many car companies are currently experimenting with these limited self-driving cars. Furthermore, governments in many countries are supporting technology development through projects and supporting it through legislation. However, as there is controversy over whether self-driving cars without human drivers can run on the road, major countries are pushing for 'driver-controlled cars'. 'Related laws are being enacted based on this.

According to Strategy Analytics, an automotive technology consulting firm, autonomous driving technology of level 4 or higher according to the Society of Automotive Engineers (SAE) standard will be commercialized in earnest around 2030 [3]. Therefore, within 10 years we will see cars running on their own on the roads. For this future, most automobile companies, as well as ICT companies such as Google and Apple, are focusing on developing level 4 to 5 autonomous driving technology.

2.2. Technologies Applied to Autonomous Vehicles

Self-driving cars can drive autonomously through an autonomous driving system. "Autonomous driving system" refers to automation equipment, software, and all related devices that enable the vehicle to operate by recognizing and judging surrounding conditions and road information, etc., without driver or passenger intervention [4].

Self-driving cars are objects that combine sensors (IoT), communication (mobile and network) big data, and artificial intelligence technologies. In order to make fully autonomous driving possible, these technologies must be more closely integrated without side effects such as errors.

In this way, autonomous driving is currently being realized in the form of Advanced Driver Assistance System (ADAS). ADAS detects external environmental information from various sensors and cameras mounted on the vehicle, and through this, notifies the driver to take appropriate actions or performs driving control on its own, providing a safe driving environment.

The system of an autonomous vehicle consists of collecting information for recognition of the driving environment, making judgments and driving strategies based on the collected information, and controlling the vehicle. In the stage of recognizing the driving environment, the surrounding environment and route are explored through various sensors, Global Positioning System (GPS), and V2X (Vehicle to Vehicle, Vehicle to Infrastructure, etc.) communication technology. It then consists of a judgment/driving strategy stage through algorithms such as big data analysis through deep learning, and finally a stage of controlling the vehicle.

For autonomous driving, it is first necessary to collect surrounding information from sensors mounted throughout the vehicle. There are many different types of these sensors. There are several types of sensors required for autonomous driving. These sensors are largely divided into LiDAR(Light Detection And Ranging), RADAR(Radio Detection And Ranging), Stereo Camera, and Ultrasonic sensors, and their installed location and role vary depending on the measurement range (angle and distance). These sensors are installed in various combinations depending on the manufacturer researching autonomous vehicles.

Among the sensor technologies for autonomous driving, LiDAR is widely used by companies, academia, and researchers researching autonomous driving, including Google, a leading company in autonomous driving technology.

LiDAR is a type of RADAR system and operates on a similar principle. RADAR is a device that emits electromagnetic waves (radio waves) toward a target object and measures the reflected wave that is reflected back from the object to measure the distance and shape of the target. The main purpose is usually to measure the distance to a distant object, and it is also applied to find the location of an aircraft or the depth of the deep sea. The difference between LiDAR is that it uses light (laser pulses) instead of electromagnetic waves.

The 3D data collected from LiDAR is used as data for autonomous driving along with information collected from RADAR, ultrasonic sensors, and cameras. It also combines with map information of the area, enabling more complete autonomous driving.

Identifying the driving environment for autonomous driving also requires image recognition technology through cameras. Through image recognition, various surrounding objects are identified while driving, and the distance to the object and spatial information are recognized. Also, there are cases where it is more advantageous to recognize through a camera. Lane recognition on the road is a representative example. Unlike objects that have quite a shape, such as car walls, guardrails, or curbs, lanes that are closely attached to the road are virtually difficult to recognize using reflected waves such as LiDAR or RADAR. Therefore, recognition of the driving environment through cameras is essential, and this supports maintaining or changing lanes of driving vehicles.

Image recognition technology using cameras is also used to recognize signs on the roadside or traffic lights. Self-driving cars recognize driving lanes, surrounding vehicle signs, people, etc. through cameras mounted on the vehicle.

In addition, among sensors for autonomous driving, super-sonic sensors are mainly used to detect short-distance obstacles within 5m and can be applied to Active Parking Assist and Auto Parking. Infrared cameras help recognize objects and determine situations for night driving.

III. AV Policy and Utilization Status in China and Korea

Today, many countries around the world recognize the development of autonomous vehicles as a national growth engine, support technology development through various projects, and promote it as national policy. The United States was the first country in the world to announce self-driving guidelines, issue self-driving licenses, and allow self-driving tests on public roads in limited areas. Even in Europe, licenses are issued in limited countries and regions. Japan also issued license plates for self-driving vehicles and allowed test drives on public roads.

However, recently, China and Korea are representative countries that are strongly promoting autonomous vehicle policies. The Chinese government's policy direction for self-driving cars focuses on support for fostering new industries. Accordingly, new related regulations are being introduced, and administrative and legal support is continuously provided. Korea has established mid- to long-term goals and plans to foster the future mobility industry as a key growth engine and is promoting these as a national task. Recently, China and Korea have established national pilot areas to test autonomous vehicle operation and are actively pursuing policies. These contents can be summarized as follows.

3.1. China's Autonomous Vehicles Policies

China has drawn up a long-term development plan for self-driving cars through the ‘Made in China 2025’ plan announced by the State Council of China in May 2015 [5]. Subsequently, in July 2017, the State Council announced the ‘Next Generation Artificial Intelligence Development Plan’ [6]. This plan aims to lead science and technology, systematically deploy, lead the market, and open source. In the first stage, lead the world level in terms of overall artificial intelligence technology and application by 2020, and in the second stage, achieve groundbreaking achievements in the basic theory of artificial intelligence by 2025. In the stage 3, the implementation goal was to reach the global level in overall areas such as artificial intelligence theory, technology, and application by 2030. Through this plan, China has established a mid- to long-term plan to incorporate artificial intelligence technology into the development of self-driving cars.

In February 2018, the Chinese government built a 133,000m^2 unmanned vehicle testing site near Beijing, and in April 2018, it announced national regulations for the nationwide legalization of autonomous vehicle road testing. And in April 2018, the Ministry of Industry and Information and Communication, the Ministry of Public Security, and the Ministry of Transportation strengthened the integration of national policies and performed various tasks. To this end, the 'Intelligent Connected Vehicle Road Test Management Standard (Test)' jointly published [7].

On February 10, 2020, China's National Development and Reform Commission announced the Smart Car Innovation Development Strategy (hereinafter referred to as the “Strategy”) [8]. This strategy seeks to establish a “smart car innovation development strategy” to identify new scientific and technological revolutions and industrial transformation trends, seize strategic opportunities for the development of industrial intelligence, and accelerate the development of smart car innovation. This strategy adjusted the existing goal of commercializing self-driving cars by 2020 to 2025, and presented the primary goal of completing the construction of mass production facilities, product management, and security systems for ‘conditional’ self-driving cars.

Here, ‘conditional’ refers to Level 3 as classified by the Society of Automotive Engineers (SAE). In addition, in August 2018, “Guiding Opinions (Implementation) on Work Related to Road Driving Tests for Autonomous Vehicles” and “Management of road driving tests for autonomous vehicles The guidance document of the Rules and Regulations (Enforcement)” has been revised. This documents refers to legal guarantees for road driving tests of self-driving cars or driverless cars.

On December 20, 2020, the Ministry of Transport of China issued “the Guiding Opinion on Promoting the Development and Application of Road Traffic and Autonomous Driving Technology” [9]. Based on basic theoretical research on autonomous driving by 2025, this “Opinion” aims to make important breakthroughs in research and development and test verification of the intelligence of road

infrastructure and core technologies and products for intelligent transportation systems, and to establish basic and core standards in the field of autonomous driving. The goal is to industrialize autonomous driving technology by establishing a national-level autonomous driving test base and pilot implementation project.

The Chinese government went further and issued an unmanned driving permit in December 2020 that allows autonomous driving tests to be conducted without safety personnel on board. The driverless driving permit allows drivers to drive on public roads with people on board, and is expected to have a huge ripple effect on the logistics and transportation industries.

As such, the Chinese government's policy direction for self-driving cars is focused on support for fostering new industries. Accordingly, new related regulations are being introduced, and administrative and legal support is continuously provided. And China has been mentioning the acceleration of the development of the artificial intelligence industry in government work reports since 2017. In this way, in China, artificial intelligence is being integrated into the development of autonomous vehicles along with electric vehicles in the context of new infrastructure. Now, in China, the self-driving car sector is being promoted nationally, being recognized as a technology field that provides basic support for the digital transformation of the industry and represents artificial intelligence.

3.2. Status of Autonomous Vehicle Operation in China (Beijing and Shenzhen)

China's self-driving car technology is developing at a rapid pace. The Chinese government is actively supporting the development of autonomous driving-related technology with the goal of commercialization in 2025. In this situation, starting in 2020, Chinese self-driving car companies such as Baidu, Didi Chuxing, and Jingdong are operating in various cities such as Beijing, Shanghai, and Changsha, and have been testing and commercializing related technologies, such as self-driving taxis and buses, in cities.

3.2.1. Self-Driving Car Companies

Self-driving cars began pilot operation in China in 2019. On September 22, 2019, the 'National Smart Connected Car Test Pilot Zone' located in Wuhan, Hubei Province was officially launched, and self-driving cars were tested and operated on a 28km long road created in this pilot zone.

Didi Chuxing launched Robotaxi, a self-driving taxi service, in Shanghai on June 27, 2020. Robotaxi operated for free on the self-driving pilot road in Jiading District, Shanghai.

Chinese self-driving startup WeRide has been piloting self-driving taxis (Robotaxi) linked to a ride-hailing app in Guangzhou and elsewhere for a year in 2020. The company announced that self-driving taxis have operated a total of 147,000 times and the cumulative number of users has exceeded 60,000, but there have been no safety accidents. WeRide recently attracted $200 million in investment and is accelerating the development and commercialization of level 4 self-driving buses that can run without driver intervention.

QCraft, a Chinese self-driving bus development company, officially launched Robo-Bus, an unmanned bus, in Shenzhen on December 29, 2020. This bus was the first self-driving bus to issue monthly transportation cards.

On December 3, 2020, Jingdong conducted a test run of an autonomous delivery vehicle operating at 10 kilometers per hour at the Xi'an Aerospace Base. In addition, when the COVID-19 infection broke out in Wuhan in early 2020, JD delivered 13,000 cases of major supplies to Wuhan No. 9 Hospital using autonomous delivery vehicles.

In 2020, due to the impact of COVID-19, the role of self-driving cars became more important in China. Due to the impact of COVID-19, positive response was received through non-face-to-face delivery, cleaning, and bus operation, and faith in commercialization further spread.

3.2.2. Baidu's Apollo

Baidu is currently leading the autonomous vehicle industry in China. Baidu Inc, a Chinese Internet search giant, launched the self-driving taxi service “Apollo Go Robotaxi” in Beijing on October 10, 2020. This taxi can be operated through the Baidu Maps APP or Apollo Go Taxi. “Apollo Go Taxi” can be called through the APP, and 40 taxis were operated within 700km of Beijing's self-driving pilot road. Safety guards were on board the vehicles for safety.

In December 2020, Baidu was also the first company in the industry to receive a driverless driving

permit from Beijing City. In this way, Baidu passed the fully autonomous driving test and secured a state in which autonomous driving testing was possible without safety personnel on board.

As of 2021, Robotaxis are operating in five cities, including Beijing, Guangzhou, Changsha, Changzhou, and Shanghai. According to Baidu, the number of passengers riding Robotaxi in 2021 exceeded 1 million, and the cumulative driving distance was calculated to be 20 million miles (approximately 32 million km). Baidu is pursuing a plan to expand Apollo Go Robotaxi, a taxi service equipped with autonomous driving technology, to 65 cities by 2025 and 100 cities by 2030 [10].

Currently, Baidu has started charging fees to users in Pingshan District, Shenzhen, China, using Apollo Go, its self-driving car-hailing service, starting January 19, 2023. There are extremely rare cases in the world where the call and transfer service for self-driving cars, which was mainly focused on test driving, has been converted to a paid service with commercialization ahead.

Before switching to this Robotaxi paid service, Baidu provided a test and demonstration platform dedicated to intelligent connected transportation targeting major transportation areas and completed a pilot service. Each individual test has completed more than 60,000 km of autonomous driving testing, and all individual services are provided in Shenzhen. Users can call Robotaxi through the 'Apollo Go' mobile application or WeChat mini program. The Baidu Robotaxi operation route covers key areas of Pingshan District in Shenzhen, China, including office centers, residential areas, shopping plazas, leisure and cultural areas, etc. Baidu plans to continue expanding the scope of Robo-taxi services in the future.

China's Shenzhen Pingshan District has previously carried out a smart transportation renovation project for highways, express national highways, major urban roads and secondary urban roads, as well as more than 180 major intersections in the region. In addition, with support from the central government, Shenzhen's first closed test site for intelligent connected vehicles is being built.

Baidu Apollo is one of the earliest startups in the autonomous driving field in China and has industry-leading technology and mature autonomous driving solutions. By the end of 2022, the total driving distance exceeded 45 million km, and it held 3,477 autonomous driving patents, ranking first in the world for four consecutive years [11].

In particular, as the Chinese government becomes more clear about its autonomous driving development strategy and direction, China's autonomous driving technology has entered an accelerated development period, and the number of companies entering the related industry is increasing. Accordingly, level 4 self-driving taxis have already appeared in Beijing and Shanghai, and self-driving cars are active in various fields such as logistics, cleaning, and tourism.

3.3. Korea's AV Policy Analysis

The Korean government's full-fledged policy promotion for self-driving cars begins with the 'Plan to support commercialization of self-driving cars' presented at the 3rd Regulatory Reform Ministerial Meeting in May 2015. This support plan provided the basis for policies related to self-driving cars, such as establishing the concept of self-driving cars and steps for each level of self-driving cars, and legislative activities such as the revision of the Automobile Management Act in 2015, which legislated the definition of self-driving cars. After this foundation was laid, the "Roadmap for Preemptive Regulation Reform in the Autonomous Vehicle Sector" was announced in 2018, presenting 30 regulatory improvement tasks in four major areas (driving entity, vehicle equipment, operation, and infrastructure). Korea's autonomous vehicle policy can be broadly divided into three categories and organized by era as follows.

3.3.1 2019 Future Automobile Vision Declaration Ceremony

The Korean government held the Future Automobile National Vision Declaration Ceremony on October 15, 2019, and jointly announced the "2030 Future Car Industry Development Strategy" with related ministries, containing the will and strategy to become a world leader in future cars by 2030 [12].

This strategy was intended to respond to innovative changes such as eco-friendliness, intelligence, and services triggered by the forecast of low growth in the global automobile market at the time, the Fourth Industrial Revolution, and strengthening environmental regulations. Specific details in the field of autonomous vehicles are as follows.

First, in 2027, fully autonomous driving (level 4) on major roads across the country will be commercialized for the first time in the world. To this end, a fully autonomous car (level 4) will be launched in 2024. Through this, Korea will become a world-class technological powerhouse by 2027.

The three major strategies to achieve these goals are as follows.

1) Actively targeting the global market through eco-friendly vehicle technology and acceleration of domestic distribution
2) Complete autonomous driving system and infrastructure (main roads) for the first time in the world by 2024
3) Rapid transition to an open future car ecosystem based on private investment (US$46 billion)

For the development of self-driving cars, ① an electrification base, ② autonomous driving functions, ③ infrastructure such as communication, and ④ institutional support are needed. In the infrastructure field, the four major infrastructures essential for fully autonomous driving, including communication, precision maps, traffic control, and roads, will be fully equipped on major roads across the country by 2024. In the institutional field, the institutional foundation related to autonomous driving will be completed by 2024, including self-driving car production and operation standards, performance verification system, insurance, and commercialization support. In the market, automakers plan to commercialize partially autonomous vehicles (Level 3) in 2021 and launch fully autonomous vehicles (Level 4) in 2024. In the technology field, the government plans to invest heavily in Level 4 autonomous vehicle systems, components, and communications to become a technology powerhouse for autonomous vehicles by 2027.

3.3.2 Enactment of the Self-Driving Vehicle Act

In Korea, the Self-Driving Vehicle Act was enacted on April 30, 2019, and is in effect as of May 1, 2020 [13]. The main contents of this law are as follows.

Unlike the Automobile Management Act or the Automobile Damage Act, the Self-Driving Vehicle Act is a special law that independently regulates only matters related to self-driving cars. As of 2019, before the above law was enacted, the positive law regulations regarding self-driving cars were the definition of self-driving cars in the Automobile Management Act (Article 2, Paragraph 1-3) and the temporary operation permit for self-driving cars (Article 27, Paragraph 1), there were only two provisions. However, this legal system had clear limitations in systematically supporting autonomous vehicle technology and markets that are rapidly changing day by day. With awareness of this problem, the Self-Driving Vehicle Act was enacted in Korea with the purpose of promoting the development of self-driving cars and creating an operation foundation by supporting research, pilot operations, and commercialization of self-driving cars and easing related regulations.

Unlike the name and purpose of the law (Article 1), the Self-Driving Vehicle Act is not a law that generally regulates the market and technology related to self-driving cars, but rather the 'Self-Driving Vehicle Demonstration Zone' (Article 2, Paragraph 1, No. 5). This is a law that stipulates 'regulatory special provisions' necessary for research and trial operation of self-driving vehicles in a specific area (hereinafter referred to as 'trial operation area'). This is because Article 3 of the Self-Driving Vehicle Act (Relationship with Other Laws) stipulates that "This Act shall be applied with priority over other laws with respect to special regulations in pilot operation zones." This is clearly evident in the fact that it is an article stipulating specific details regarding special regulations in the pilot operation zone. The main contents of this law are briefly summarized as follows.

This law stipulates the establishment and promotion of autonomous vehicle policy as follows.

> *The Minister of Land, Infrastructure and Transport shall establish an 'Autonomous Driving Transportation and Logistics Basic Plan' (hereinafter referred to as 'Basic Plan') every five years for the introduction and expansion of autonomous vehicles and the development of an autonomous driving-based transportation and logistics system (Article 4, Article 4). Paragraph 1), has the discretion to establish and implement annual implementation plans in accordance with the basic plan (Article 4, Paragraph 3).*

Subsequently, designation, operation and management of the pilot operation area were stipulated.

> *The pilot operation zone is an area where various regulatory special provisions stipulated in the Self-Driving Vehicle Act apply. The pilot operation district is designated by the Minister of Land, Infrastructure and Transport after receiving an application from a city or provincial governor and following deliberation and resolution by the 'Autonomous Vehicle Pilot Operation District Committee' (hereinafter referred to as the 'Committee') (Article 7).*

Subsequently, the Self-Driving Vehicle Act has provisions that explicitly exclude regulations under

existing laws with respect to paid transportation of passengers and cargo using self-driving vehicles, automobile safety standards, etc. within the pilot operation zone (Articles 8 and Article 13). In this way, the Self-Driving Vehicle Act can be considered a special regulation law.

3.3.3 Announcement of 2022 Mobility Innovation Roadmap

On September 19, 2022, the Korean government announced the 'Mobility Innovation Roadmap' containing mid- to long-term goals and plans to foster the future mobility industry as a key growth engine [14]. The key point is to commercialize fully autonomous vehicles with 'level 4' performance that do not require driver intervention by 2027, and to increase the penetration rate of new vehicles with autonomous driving functions to more than 50% by 2035. In the mobility innovation roadmap, the content of 'the opening of the era of fully autonomous driving without the need for a driver' is largely composed of three parts.

1) Self-driving service becomes established in everyday life

By the end of 2022, Korea will commercialize partially autonomous vehicles (Level 3) and transform the existing public transportation system to one based on autonomous driving through the commercialization of fully autonomous buses and shuttles (2025) and zone operation services (2027). To this end, the current passenger transportation system will be reviewed to be compatible with autonomous driving by 2024, and a plan to reform the passenger transportation system will be preemptively prepared.

Subsequently, support for the private sector will be expanded to develop and expand new services using autonomous driving, such as mobility support for the transportation vulnerable and priority passage for emergency vehicles.

2) Innovation in autonomous driving regulations

In order to preemptively resolve uncertainties in the private sector that are working to commercialize fully autonomous driving in 2027, a level 4 system will be prepared by 2024. Specifically, we established automobile safety standards (production standards), including Level 4 vehicle systems (response to defects, etc.), driving safety (ensuring safety in case of collisions, etc.), and operated a separate performance recognition system even before establishing standards to support unrestricted operation of autonomous driving vehicles.

To enable free demonstration of autonomous driving technology and services, the Ministry of Land, Infrastructure and Transport will designate at least one autonomous vehicle pilot operation district in each city and province nationwide by 2025 through the introduction of a system for autonomous vehicle pilot operation district designation by the Ministry of Land, Infrastructure and Transport.[2], Afterwards, all autonomous vehicle pilot operation districts except for specific districts will be designated. We will significantly expand regulatory special cases by introducing a negative method in which regulatory special cases are applied in the region.

3) Construction of autonomous driving-friendly infrastructure

Korean government support the autonomous driving system by overcoming the limitations of vehicle sensors through the nationwide establishment of real-time communication infrastructure between autonomous vehicles and autonomous vehicles and autonomous vehicles and infrastructure. Real-time communication infrastructure will be built on roads nationwide (approximately 110,000 km) by 2030, but congested areas such as city centers, where support for autonomous driving systems is especially required, will be built proactively by 2027 through collaboration with local governments. Specifically, it will be built in the following order: (Phase 1~2023) major highways → (Phase 2~2027) city centers and major roads nationwide → (Phase 3~2030) roads across the country. The communication method will be based on the direct communication method (WAVE or C-V2X), but in non-congested areas, a hybrid method will be promoted, such as rapid construction by utilizing the existing mobile communication network (V2N method).

In the first half of 2023, the first mobility innovation highway will be selected to demonstrate various autonomous driving services such as autonomous platooning of freight vehicles by designating and operating autonomous driving-only lanes on existing highways.

[2] Previously, designation was possible only upon application by the head of a local government, which limited the designation and operation of districts in metropolitan areas such as cities and provinces. However, this has been improved and the ex officio designation of the Minister of Land, Infrastructure and Transport has made it possible to operate districts in a diverse range of regions.

3.4. AV Pilot Project in Korea (Seoul)

In Korea, the self-driving car pilot district is a newly introduced system in accordance with the "Self-Driving Vehicle Act" that came into effect in May 2020. The pilot zone is an area that can receive special treatment necessary for providing autonomous driving services, and has been continuously expanded six times since it was first introduced in May 2020. In addition, the Korean government established safety and ethics regulations and guidelines for the production of self-driving cars [15][16]. As of July 2023, the area where autonomous driving mobility services are available covers 24 districts in 15 cities and provinces across the country.

Through the expansion of pilot operation zones, the government will ensure that citizens can easily experience and use the convenience of autonomous driving technology anywhere in the country, and the government will play a role such as budget support and system maintenance to encourage the creation of new business models through pilot operation districts which is planned to be further expanded. Among these pilot districts, Seoul has the most designated areas, with five areas (Sangam, Gangnam, Cheonggyecheon, Blue House, and Yeouido). The current status of autonomous vehicle operations in Seoul is summarized as follows.

In Sangam, Seoul, which was designated as Korea's first 'self-driving demonstration district' and began proactive technology demonstration and infrastructure construction, four self-driving taxis began free test operation in shuttle mode from the end of November 2021. Subsequently, paid operation began in February 2022. There are two routes that circulate around DMC Station, and using the dedicated smartphone application 'TAP!', you can set the departure and destination points within the designated route and travel by paying 2,000 won (about 2 dollars). Subsequently, the number of self-driving taxi vehicles was increased from 4 to 7, and one 15-seat small bus was included. However, it faced criticism for its low utilization rate.[3] Seoul City plans to expand the number of autonomous vehicles to more than 50 by 2026 in the Sangam area alone.

Subsequently, in 2022, a 'Robo Taxi' was pilot operated in Gangnam, Seoul, where the starting point and destination are selected and called with a smartphone. In particular, the Gangnam area is rapidly moving towards the commercialization stage, with level 4 robotaxi (unmanned self-driving taxi) operating from early 2023. The Seoul Metropolitan Government plans to expand the number of self-driving buses and robotaxi circulating within Gangnam to more than 100 by 2026.

For the development and trial operation of private autonomous vehicles such as robotaxi, the city of Seoul has digitized traffic signal information from 129 locations in the Gangnam area starting in September 2020, and has calculated the color of traffic lights and the time remaining until the next signal to change in 0.1 second increments. Seoul city have established autonomous driving support infrastructure (Cooperative-Intelligent Transport Systems: C-ITS), including providing it to self-driving cars.

In addition, Cheonggyecheon and Yeouido in Seoul have been designated as 'autonomous driving demonstration zones', and autonomous buses for urban circulation are being tested and autonomous vehicle bases are being expanded.

The city of Seoul has set a goal of building autonomous driving infrastructure on all roads with two lanes or more in Seoul by 2026, while gradually introducing services that citizens can use in their daily lives to become a top 5 autonomous driving city by 2026. Seoul city plan to increase the city's competitiveness by raising it to the top 3 in the world by 2030. [4]

To this end, the mayor of Seoul announced the "Seoul Autonomous Driving Vision 2030" in November 2021 [18]. This "Seoul Autonomous Driving Vision 2030" is promoted with five major tasks. ①Expansion of autonomous vehicle bases (autonomous vehicle pilot operation zones) and commercialization of mobile services ②Operation of self-driving buses in Cheonggyecheon ③Establishment of self-driving buses as a means of public transportation ④Introduction of autonomous vehicle-based urban management in the public service sector ⑤Establishment of autonomous driving

[3] According to the Seoul Metropolitan Government, as of May 2022, 'TAP!' The total number of subscribers was 3505. Starting with 2,144 people in February 2022, 619 people signed up in March → 369 people in April → 373 people signed up in May. The number of calls ranges from 265 in February → 315 in March → 184 in April → 156 in May. Even though it operates 5-6 days a week (1 vehicle operating on 5 days, 3 vehicles operating on 6 days) excluding Sundays and public holidays, it only receives about 9-10 calls per day [17].

[4] According to KPMG's 2020 report (2020 Autonomous Vehicles Readiness Index), Korea's autonomous driving readiness status ranks 7th in the world.

infrastructure throughout the city. To this end, Seoul city plan to invest 115 million US dollars from 2022 to 2026.

IV. Analysis of AV Test Operation Status in Xiong'an New Area, China

Unlike Sejong City in Korea, China's Xiong'an New District is a new city that seeks to relieve overcrowding in the capital by relocating various fields such as education, research, and finance, excluding Beijing's administrative functions. Since its launch on April 1, 2017, Xiong'an New Area has promoted 177 key projects over the past five years and invested 618.4 billion yuan (approximately US$91 billion) to become an innovative and eco-friendly new city. As of 2021, 258 technologically innovative companies have moved in, and 100 medical institutions and 60 schools in Beijing, Tianjin, and Hebei Province are in place. China has designated Xiong'an New Area as a special zone for autonomous vehicle operations, and test operations are currently in progress.

4.1. Xiong'an New Area Overview

In April 2017, the Chinese government announced the establishment of the Xiong'an New Area. According to an official statement released by the central government, the establishment of the Xiong'an New Area is a major decision and deployment by Xi Jinping to promote the synergistic development of Beijing-Tianjin-Hebei and is a key strategy for the next millennium. The central government hopes to build Xiong'an New Area into an open, high-tech, smart and eco-friendly city through policy innovation and infrastructure improvements. To this end, the Chinese government plans to invest more than RMB 800 billion in the construction of key projects [19].

Xiong'an New Area is a smart city to be built by 2035 in rural Hebei Province, about 100km southwest of the capital Beijing. It is the third special zone at the national level, following the Shenzhen Special Economic Zone in Guangdong Province and the Pudong New Zone in Shanghai, and will share urban functions with Beijing. The final area is 2,000 ㎢, which is much larger than Seoul (605 ㎢) and close to Tokyo, Japan (2,134 ㎢). Xiong'an New Area, a future city that Chinese President Xi Jinping is promoting as part of China's "millennium plan", will be built as a smart city with self-driving cars running on the roads.

Smart city construction is one of the key projects to be promoted in Xiong'an New Area, and the planning outline shows that Xiong'an New Area wants to synchronize the planning and construction of the digital city with the real city, and to build a globally leading smart city with deep learning capability. To this end, the Chinese government is vigorously promoting the construction of new infrastructure, including information network infrastructure, data computing platform infrastructure, converged industry application infrastructure and innovation platform infrastructure. At present, Xiong'an New Area has realized full network coverage of NB-IoT, built a data center, Xiong'an Cloud Platform, and put in a supercomputing center that initially meets the scale of about 2pflops of computing power. These infrastructures support autonomous driving testing and development.

Currently, regarding the development of self-driving car technology in China, the pace of development is being accelerated through a national mobilization system. Internet giant Baidu, which participated in the development of Xiong'an New Area, has begun research on artificial intelligence (AI) driving technology with the Hebei provincial government and is developing transportation infrastructure and self-driving cars as an integrated system. Baidu began testing self-driving cars using the next-generation communication standard 5G with state-run telecommunications company China Telecom in Xiong'an New Area in March 2018.

4.2. AV Test Operation Status

In order to be able to realize higher levels of autonomous driving in the future, the Xiong'an New Area District has adopted the technology route of Vehicle Infrastructure Cooperated Autonomous Driving（VICAD）, and the work focuses on the construction of Smart Transportation infrastructure and the trial operation of autonomous vehicles.

4.2.1 Smart Transportation Infrastructure

Regarding the Smart Transportation infrastructure construction, on November 18, 2022, the first digital road in Longdong(容東) District, Xiong'an New Areas entered formal operation. The digital road built in Longdong District of Xiong'an New Areas is part of the construction of a 'digital smart city' in Xiong'an New Areas. The digital road is 153km long and connects the 12.7㎢ Longdong District. All municipal roads such as main roads, secondary roads, side roads, street roads, tunnels and other municipal roads are fully deployed with intelligent facilities such as multi-functional information poles, cameras, radars, 5G, edge computing nodes, roadside RSUs, vehicle-mounted OBUs and other intelligent facilities, and through the application of new technologies such as edge computing and cloud computing synergism, video and radar synergism, and dynamic and high-precision digital maps.

This digital road realizes data collection, aggregation and real-time transmission of the full amount of traffic data, such as image data, radar data, state perception data, etc., enables real-time interconnection and intercommunication among people, vehicles, roads and things, thus enhancing the level of services such as traffic management and public travel, and accelerating the application of unmanned driver technology. The planned construction of Intelligent digital roads in Xiong'an New Area is 500 kilometers, and as of July 2023, about 200 kilometers have been completed [20].

4.2.2 Autonomous Vehicle Test Run

In 2017, Baidu's Apollo autonomous driving platform signed a strategic cooperation agreement with Xiong'an New Area and established the Apollo Xiong'an institute for intelligent Transportation. This organization, which is centered on autonomous vehicles, intelligent road network and vehicle-road synergy, to carry out policy and regulation innovation research, automatic driving scene application, intelligent road network facilities construction, vehicle-road collaboration platform test, intelligent transportation education and training, and continuously invest in L4-level autonomous vehicles testing in Xiong'an New Area.

Smart autonomous vehicle road testing and pilot operation in Xiong'an New Area officially began in April 2022. In the first test, six roads with a total length of 25 km were selected in Longdong District, Xiongan New District, and a route operation test was conducted between two points. For the first test, 18 self-driving vehicles were prioritized. The scope of subsequent road tests continues to expand, and by the end of 2022, more than 100 various autonomous vehicles have participated in road tests and pilot applications.

Through this test, Xiong'an New Area sought to build a new smart transportation system in which people, vehicles, roads, and objects are interconnected in real time, sensed in real time, react immediately, and make smart decisions. In addition, Xiong'an New Area promote full opening and sharing of data, build a big traffic database, prepare traffic data such as cameras, radar, traffic lights, and high-precision maps, perform vehicle test data masking, and share data between participating organizations. Furthermore, Xiong'an New Area will accelerate the construction of infrastructure such as digital roads, edge computing, hash centers, etc., improve related policy systems, and enable various automobile and science and technology enterprises to develop core technologies and discover new application cases.

With regard to the trial operation of autonomous vehicles, Xiong'an New Area is the first city in China to incorporate autonomous vehicles into its public transport operations and has put into practice the realization of an L4-level autonomous driving bus for the operation of the 901-bus route. The buses are equipped with 6 LIDARs, 5-millimeter wave radars, 16 ultrasonic radars, and 12 HD cameras set around the body, which, combined with the navigation function, can realize the environmental perception within 240 meters around the vehicle. During the driving process, the vehicle can realize driving with the car, changing lanes to overtake, passing through traffic light intersections, and entering and exiting the park of the vehicle under the state of automatic driving. Vehicle decision-making response speed within 100 milliseconds, encountering pedestrians and obstacles will automatically decelerate 20 meters in advance, and can realize emergency braking within 2 meters when obstacles suddenly intrude. By the end of 2023, three self-driving bus routes, 901, 902 and 903, will be opened [21].

4.3. Implications for AV Test Operations

The implications that can be gained from the self-driving car test run in China's Xiong'an New Area can be summarized as follows.

4.3.1 Central Government Policy Support

The development of high technology, such as autonomous driving, is seen by the Chinese government as a key project to enhance international competitiveness and industrial upgrading. According to some data, since 2010, about 49.18% of high-level (L4 and L5) autonomous driving patents originated from China [22]. This is due to the Chinese government's strong focus on the autonomous driving industry. Similarly, the autonomous driving project in Xiong'an New Area is led by the government, with relevant ICT companies cooperating with the government to complete the construction and testing. The Chinese government has provided many favorable policies, including infrastructure construction, provision of real-life scenarios to help ICT companies complete testing, improve laws and regulations, matching funds, tax breaks, and data sharing. In addition, the attention paid by China's top leaders to the development of Xiong'an New Area was also key to the smooth development of the project.

4.3.2. Technology Development Roadmap (Infrastructure)

On the basis of Autonomous Vehicle, China has evolved the technology route of Vehicle Infrastructure Cooperated Autonomous Driving, which, with the help of C-V2X and 5G communication technology, the "human-vehicle-road-cloud" traffic elements are organically linked together to realize the all-round cooperative cooperation of vehicle and vehicle（V2V）, vehicle and Infrastructure（V2I）, vehicle and Network（V2N）and vehicle and people (V2P), etc., to enhance the perception, decision-making and control capabilities to cope with the complex and changing road conditions and traffic environment, and ultimately realize the goal of fully automatic driving and traffic global optimization.

4.3.3. Economy of Scale

In terms of the penetration rate of self-driving cars, the Chinese government proposes that the penetration rate of Autonomous Vehicle should reach 80% by 2025, of which the penetration rate of L2 and L3 should reach 25%, and high-level Autonomous Vehicle (L4 level and above) will start to realize large-scale application. In addition, the Chinese government proposes to formulate a Chinese version of fully automated driving standards by 2030 and realize the localization of the automated driving industry chain to reach more than 40%. With the gradual increase in penetration rate and the industrial chain localization strategy, the scale of China's domestic self-driving car industry will also grow rapidly.

V. Analysis of AV test operation status in Sejong City, Korea

In the early 2000s, discussions on the construction of Sejong City in South Korea began at the level of relocating the capital. However, as only the administrative functions of the capital were decided to be transferred, the scale was reduced and it was promoted from 2012. Accordingly, central ministries, public institutions, and research institutes were relocated.

5.1. Sejong City Overview

Sejong Special City was launched as the 17th metropolitan government in Korea on July 1, 2012. The area is 464.90㎢, and the population is 385,953 (as of 2023). [5] The area where the multifunctional administrative city was built is only a portion of 72.91㎢. The multifunctional administrative city was planned as a city that included only administrative functions and complex city functions, excluding the capital function from the functions of the new administrative capital. In general, a true capital must have all three functions - administrative, legislative, and judicial - but Sejong City has decided to transfer only the administrative functions.

Sejong Special Self-Governing City is an administrative city, and private institutions were relocated sequentially in 2010 and government institutions were relocated in 2012, and the relocation was completed by 2014. As of 2021, there are 45 central administrative agencies and affiliated organizations, 15 government-funded research institutes, and 9 additional public institutions that have been relocated. Additionally, the Prime Minister's residence was established.

[5] When launched in 2012, the population was approximately 115,000. Afterwards, the population exceeded 200,000 in 2015, and entered the 380,000 range in February 2022. The target population by 2030 is 800,000.

Sejong City is the largest new city in the history of Korea. However, there is some confusion among the general public regarding the concepts of Sejong City and multifunctional administrative city. Furthermore, this confusion is aggravating as the Korean government has designated the 5-1 area in Sejong City as a smart city national pilot area [23].

The multifunctional administrative city refers to the central city area that is a certain part of the current Sejong City and is being built by the Multifunctional Administrative City Construction Agency under the Ministry of Land, Infrastructure and Transport, which was opened in 2006. Construction projects in the multifunctional administrative city area are being carried out by the Multifunctional Administrative City Construction Agency, and construction in other incorporated areas is being carried out by Sejong City, a local government established in 2012. Therefore, it can be seen as a somewhat bifurcated regional development structure. Currently, about 2/3 of the total population of Sejong City lives in the central city, which is the city center, and as concentration will intensify in the future, the perception that 'Sejong City = central area (new city)' will gradually deepen.

Sejong City was built as a smart city, but it has been more than 10 years since its completion. Currently, resolving traffic congestion is pointed out as the biggest problem for Sejong City residents. As a result of a survey conducted by the Korea Transport Institute in 2018 on what the most inconvenient thing was for Sejong citizens, “transportation problems” accounted for the absolute majority at 58.3%. (Next is culture and leisure at 24.7%, education and medical care at 11.5%, etc.) [24]. The reason is because of the narrow roads in Sejong City. The road ratio in Sejong City is around 24%, which is quantitatively not lower than that of other cities. However, the internal road network of Sejong City was planned to be decentralized and non-hierarchical in accordance with the urban ideology of ‘equality’ and ‘dispersion’ of the winning work of the international competition at the time of design, with relatively narrow roads of less than four lanes, without wide highways or boulevards. This is a human-centered democratic transportation plan, which is a major feature and advantage of Sejong City, but drivers who are accustomed to wide roads centered on cars are not used to it, so they feel that the roads are narrow. Because of these problems, Sejong City was selected early on as a pilot area for self-driving cars.

5.2. AV Test Operation Status

From December 27, 2022, in Sejong City, a self-driving bus exclusively for Bus Rapid Transit (BRT) operating on a 22.4km section between Osong Station and Sejong City Bus Terminal began trial operation. Self-driving buses were given separate route numbers, A2 and A3, and began operating together with existing regular city buses such as B0, B2, and B4 [25].

These self-driving buses in Sejong City utilize the existing BRT system. BRT is a public transportation system that improves punctuality and capacity by separating bus traffic from regular vehicles. Although the transportation volume is very small compared to that of urban railways, it can provide services comparable to Light Rail Transit (LRT) at low construction costs, so it is attracting attention as a transportation demand management measure in many cities. In Sejong City, BRT was installed in April 2013 to handle the transportation needs of the multi-functional administrative city with inadequate rail transportation.

Self-driving buses operated in Sejong City in early 2023 are electric buses (14-seat Apollo 750, 2 units) and regular passenger buses (15-seat Resta, 1 unit) equipped with level 3 autonomous driving technology. The driver and safety personnel were on board to support safe operation, including assisting with boarding and disembarking, autonomous driving guidance, and quick response to emergency situations. These three BRT-only self-driving buses, equipped with level 3 autonomous driving technology, operated six round trips at approximately 40-minute intervals from 12:00 PM to 4:00 PM, Monday through Friday, excluding weekends and public holidays, until May 23, 2023. It stopped at eight stop stations along the existing BRT line.

Sejong City's self-driving buses were available for free to anyone who applied for a pre-experience through the QR code on the Sejong City website or on the BRT stop poster. It was planned to be converted to a paid service (city bus fares applied) after conducting a pilot operation for about 5 months and reflecting the opinions of citizens who used the service, but as of the second half of 2023, operation has been suspended.[6] The current status of AV test operations in Sejong City is summarized as follows.

[6] In the case of Sejong City, commercial operation of self-driving buses began on October 6, 2023. However, since it only runs four times a day, there are very few users.

- Operating period: December 27, 2022 – until the end of May 2023
- Operating section: Sejong City Bus Terminal – Osong Station BRT road (22.4Km)
- Operating hours: Weekdays (Monday-Friday, excluding weekends and public holidays, 12:00 - 16:00, departure interval 40 minutes)
- How to use: For use only by those with advance reservations, operates on a seating system for passenger safety.

Sejong City's BRT self-driving bus service is Korea's first self-driving bus to be introduced on a main road, and the Sejong-Daejeon (Sejong Terminal ↔ Banseok Station, 9.8km) BRT section is scheduled to be added in the second half of 2023. After 2024, service expansion to major areas in the Chungcheong region, including Cheongju International Airport, is planned.

This Sejong City BRT self-driving bus service was realized through close cooperation with related organizations. The Ministry of Land, Infrastructure and Transport changed and designated the Sejong-Chungbuk pilot operation zone at the end of 2022, and the Metropolitan Transportation Committee revised related regulations to allow autonomous vehicles to drive in the BRT section.

5.3. Status of AV Support in Sejong City

In order to support the operation of self-driving cars, Sejong City is supporting the development of self-driving car-related industries by establishing an autonomous driving big data control center and autonomous driving research and verification support facilities. The Sejong City Big Data Control Center is located on a site of 465.57 ㎡ and provides an open lab for autonomous vehicle control, big data analysis and processing, and technology development design.

The Autonomous Driving Big Data Control Center is responsible for collecting and analyzing data such as autonomous vehicle control and V2X (vehicle-to-object communication) linkage. In addition, roadside base stations were installed in the BRT section and a 10km section of general roads to build a test bed for self-driving cars and provide modules for communication between vehicles and infrastructure to self-driving car companies, helping companies reduce costs and shorten the technology development period [26].

The control center monitors real-time control and vehicle breakdown status to ensure the stability of self-driving cars, and has established Korea's largest self-driving data storage space of 9PB (9 million GB) to store large amounts of raw data such as video and LiDAR data.

Sejong City is currently collecting autonomous driving data by deploying two passenger vehicles, and plans to collect a large amount of data by deploying autonomous vehicles on BRT routes, Central Park, and Lake Park in the future. The collected data will be used as learning data to develop analytical models such as accident risk area prediction model, demand-driven autonomous vehicle route optimization model, and roundabout recognition model.

In addition, the Self-Driving Research Facility is a facility built over 6 buildings on the first floor, and can store 6 self-driving buses and 16 self-driving passenger cars, as well as a research building equipped with 3 types of electrical component reliability test equipment. A garage, facilities for light maintenance, and an inspection building with equipment have been built. In the past, Sejong City's growth strategy in the early stages of urban development was to attract institutions, but in the future, it is supporting the development of the future autonomous vehicle industry through cutting-edge technology.

VI. Policy Implications and Advices

So far, we have analyzed the self-driving car-related policies and test operation status in China and Korea. China and Korea have identified the autonomous vehicle industry as the country's future growth engine and are actively supporting it. In particular, two country governments are setting up a test operation area and preparing for the commercialization of self-driving cars. By comparing and analyzing the self-driving car policies of China and Korea, we would like to make policy suggestions based on the implications derived.

6.1. Implications of comparative analysis results

China and Korea are currently two countries that are at the top of the world in the field of self-driving cars. However, the policy for promoting self-driving cars shows a slightly different picture. Furthermore, many differences appear in the test run of Xiong'an New Area and Sejong City. Of course, it is not easy to directly compare Xiong'an New Area and Sejong City, but since the two cities have similarities in many ways, the following policy implications can be drawn.

6.1.1 Leadership in AV Policy Promotion

Since the promotion of policies related to self-driving cars is future-oriented rather than current, many difficulties are encountered during the practical implementation stage. In particular, China's Xiong'an New Areas and Korea's Sejong City are new cities and smart cities that did not exist in the past, making policy implementation more difficult. Both cities are newly built cities by relocating a certain portion of the functions of existing capital cities such as Beijing and Seoul. Therefore, the interest and will of the top leader are very important in the construction of cities as well as the operation of self-driving cars [27] [28].

From this perspective, China's Xiong'an New Area is absolutely ahead of the curve. The reason is that, just as China's Deng Xiaoping promoted Shenzhen as a symbol of reform and opening in the 1980s, today's President Xi Jinping is highlighting Xiongan New Area as a symbol of 'digital China'. Xiong'an New Zone, called 'Xi Jinping Special Zone', is the third national-level special economic zone following Shenzhen Special Zone and Shanghai Pudong New Zone. It is a grand plan that has been promoted since April 2017 to disperse the functions of the overcrowded capital Beijing.

Since then, Xi Jinping has visited Xiongan New Area in person almost every year to encourage city construction. This year, in 2023, he visited Xiong'an New Area and inspected the operation status of self-driving cars [29]. Therefore, the interest and leadership of these leaders are acting as a major driving force for the operation of self-driving cars in Xiongan New Area.

In comparison, Korea's Sejong City has a relatively long history of more than 10 years and its foundation has been completed to some extent, so the top leader's interest is inevitably less. Therefore, currently in Korea, the president has not visited Sejong City to discuss the future of the city or further expressed interest in the operation of self-driving cars.

6.1.2 AV Agenda as a National Policy

Currently, China's Xiong'an New Area is a special economic zone promoted at the national level. Initially, development will be carried out on an area of 100 ㎢, but the scope will gradually be expanded, and an area of 2000 ㎢ will be developed in the long term. This is approximately 3.3 times the area of Seoul (605 ㎢).

Shenzhen, the first special economic zone, was once a fishing village, but has now become a world-class city of manufacturing, social media, and drones. So what is the future of Xiong'an New Area, which is currently a rural area? According to the current plan, there is a high possibility that it will become a city for the new automobile industry, that is, the 'smart mobility industry' in the digital era.

In this process, Xiong'an New Area is promoting various policies based on strong support from the central government, including the State Council. Xiong'an New Area is not simply a new city being built, but a testing ground for the Chinese government's digital policies, especially autonomous vehicle policies.

Therefore, along with the construction of Xiong'an New Area, an exclusive lane for self-driving cars was first built on the 100 km long highway connecting the capital city of Beijing and Xiong'an New Area in Hebei Province. The Chinese government plans to use two of the eight round-trip lanes exclusively for self-driving cars. With the completion of a dedicated road for self-driving cars, the time it takes to travel from Beijing to Xiong'an New Area by car has been greatly reduced to one hour. Furthermore, a high-speed rail line has been completed between Beijing and Xiong'an New Area, and a new airport is also open and operating.

In this way, policies for Xiong'an New Area are being promoted at the national level. In comparison, Sejong City encountered opposition from local residents at the time of construction, so it is not connected to a highway and connectivity with high-speed rail is low. And currently, Sejong City's autonomous vehicle policy is being promoted at the local government level according to zone designation by the Ministry of Land, Infrastructure and Transport. Therefore, it is difficult to secure a strong government-wide driving force.

6.1.3 AV Policy Implementation Method (Corporate vs. Government)

First of all, the self-driving car policies of China and Korea can be found in common in that the governments are actively promoting them from the perspective of future growth engines. However, the process of actually implementing self-driving car policies shows different aspects. The reason appears to be differences in the way policies are implemented. First of all, it shows differences from two major perspectives.

The first is the aspect of combination with artificial intelligence. The Chinese government emphasized convergence with artificial intelligence from the early stages of its autonomous vehicle policy. As a result, rapid growth has been achieved through combination with artificial intelligence in the development and application of autonomous driving technology. This was, of course, because the State Council was able to promote government-wide policies at the center of policy.

A representative example can be found in the four 'artificial intelligence (AI) special zones' envisioned by President Xi Jinping. In China, from the south, Shenzhen is the center of healthcare (medical imaging), Hangzhou is the smart city, Hefei (Anhui Province) is the center of voice recognition, and the Beijing area (including the Xiongan New Area) is the center of autonomous driving. It has been designated as a district and is being actively promoted. Therefore, autonomous driving in Xiongan New Area is not simply a vehicle operation, but is being carried out at the level of China's artificial intelligence special zone.

However, in the case of Korea, self-driving cars are under the jurisdiction of the Ministry of Land, Infrastructure and Transport, and artificial intelligence is under the Ministry of Science and ICT. Therefore, if the two ministries do not collaborate, the two policies will have no choice but to proceed separately. The Korean government is also aware of these problems and is trying to promote artificial intelligence policies on a government-wide basis, but has not yet achieved convergence with self-driving car policies. Therefore, the role of the Ministry of Science and ICT in Sejong City's autonomous vehicle test operation does not appear.

The second is the active participation of companies. In order to support artificial intelligence policies, the Chinese government is targeting large corporations as central companies in each field, such as Tencent for medical imaging, Alibaba Group for smart cities, iFLYTEK for voice recognition, and Baidu for autonomous driving. These are collectively called China's 'four major platformers.' Among them, autonomous driving is a key area of President Xi Jinping's plan, and the purpose of the development of Xiong'an New Area is to solve traffic congestion, air pollution, and the economic gap between large cities and their surroundings at once.

In this way, the test operation of self-driving cars in Xiong'an New Area in China is being conducted mainly by companies, but the test operation of self-driving cars in Sejong City, Korea is being conducted mainly by local governments. Therefore, it has limitations that lag behind in the application and utilization of new technologies.

6.1.4 Timing of AV Commercialization

Currently, pilot operations of Level 3 self-driving cars are continuing in China's Xiong'an New Area and Korea's Sejong City. Considering the above discussion, there is a possibility that Level 4 commercialization of autonomous vehicle operation will proceed earlier in China's Xiong'an New Area than in Korea's Sejong City.

There may be many reasons, but they can be explained simply by broadly defining the meaning of commercialization. Commercialization means that citizens, who are consumers, pay money to use the service. Therefore, this requires a business model that guarantees profitability. This business model has so far been active in the private sector, that is, private companies, rather than the public sector.

In China's Xiong'an New Area, self-driving car testing is currently underway, led by Baidu. Baidu is commercializing self-driving taxis in various regions of China and is acquiring various know-how in this sector.

In comparison, the local government of Sejong City in Korea is conducting self-driving car tests and does not have the know-how for commercialization. Additionally, the test operation area is also extremely limited. Therefore, regardless of the technological perspective of self-driving cars, commercialization of self-driving cars will occur first in Xiong'an New Area rather than in Sejong City. Korea has been a world leader in the fields of e-government and digital government [30][31]. However, in the field of commercialization of artificial intelligence and autonomous vehicles, China is likely to be ahead of Korea.

6.2. Policy Advices: Paradigm Shift in Goals for AV Policy Promotion

In summary, we would like to make the following suggestions regarding future self-driving car policies. Currently, both Korea and China have set autonomous vehicle policies as one of the future national development growth engines and are promoting them as part of the smart mobility industry. Of course, this is inevitable in order to respond to environmental changes in the existing automobile industry and intensifying global industrial competition [32][33].

However, the promotion of this autonomous vehicle policy must now be approached in a new way that is different from the past. In the past, the government used the method of allocating a budget, selecting a company, and entrusting it with the project. This method was used in the past when promoting e-government projects. Now, in digital government, the government must break away from leading policies and support the private sector to lead policies and actually implement them.

Furthermore, the scope of the policy should be expanded so that the promotion of autonomous vehicle policy goes beyond strengthening industrial competitiveness and constitutes the basis of an intelligent information society in the era of digital transformation. In fact, the operation of self-driving cars is not simply the operation of driverless cars, but involves total innovation that must be accompanied by changes in all areas of society as a whole. Therefore, many problems appear that cannot be solved through the introduction and use of artificial intelligence or big data alone.

Specifically, if self-driving cars are mainly operated in large cities and new cities, an imbalance will occur in the group of beneficiaries of these policies. In other words, there are concerns that it will be perceived as a policy only for the rich and wealthy citizens. Therefore, a universal service perspective that can benefit all citizens must be considered from the beginning of policy implementation.

In particular, efforts should be made to resolve the digital divide from past informatization policies and the transition to today's digital inclusion policy should be learned as a lesson. Therefore, policies and systems must be preemptively reorganized so that self-driving cars can go beyond changing the lives of city citizens and urban space and become an important means of transportation for the socially disadvantaged.

VII. Conclusion

Both South Korea and China have set autonomous vehicles as a future national growth engine and are pursuing policies to support the industry. Korea is pursuing policies aimed at commercializing the world's highest level of fully autonomous driving (Level 4) in 2027. The Chinese government is also supporting policies aimed at commercializing Level 4 to Level 5 autonomous driving technology after 2025. In this study, we compared and analyzed the status of autonomous driving tests being conducted in China's Xiong'an New Area and Korea's Sejong City. As a result, it was found that in Korea, autonomous driving tests are being conducted limitedly and only on designated routes. In the case of Xiongan New Area, autonomous driving is being implemented on more routes than in Sejong City. Therefore, in the case of autonomous driving commercialization, China is ahead of Korea and is progressing in large cities.

China, which started developing autonomous driving technology one step later than the United States, is sparing no institutional and financial support at the government level with the goal of securing global technological superiority, and companies are also making large-scale investments and technological innovations to dominate the market. The Korean government has also abolished regulations related to autonomous driving and is actively supporting it. Therefore, we must continue to watch with interest whether China and Korea will be able to secure global competitiveness along with the United States in the field of autonomous driving in the future.

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