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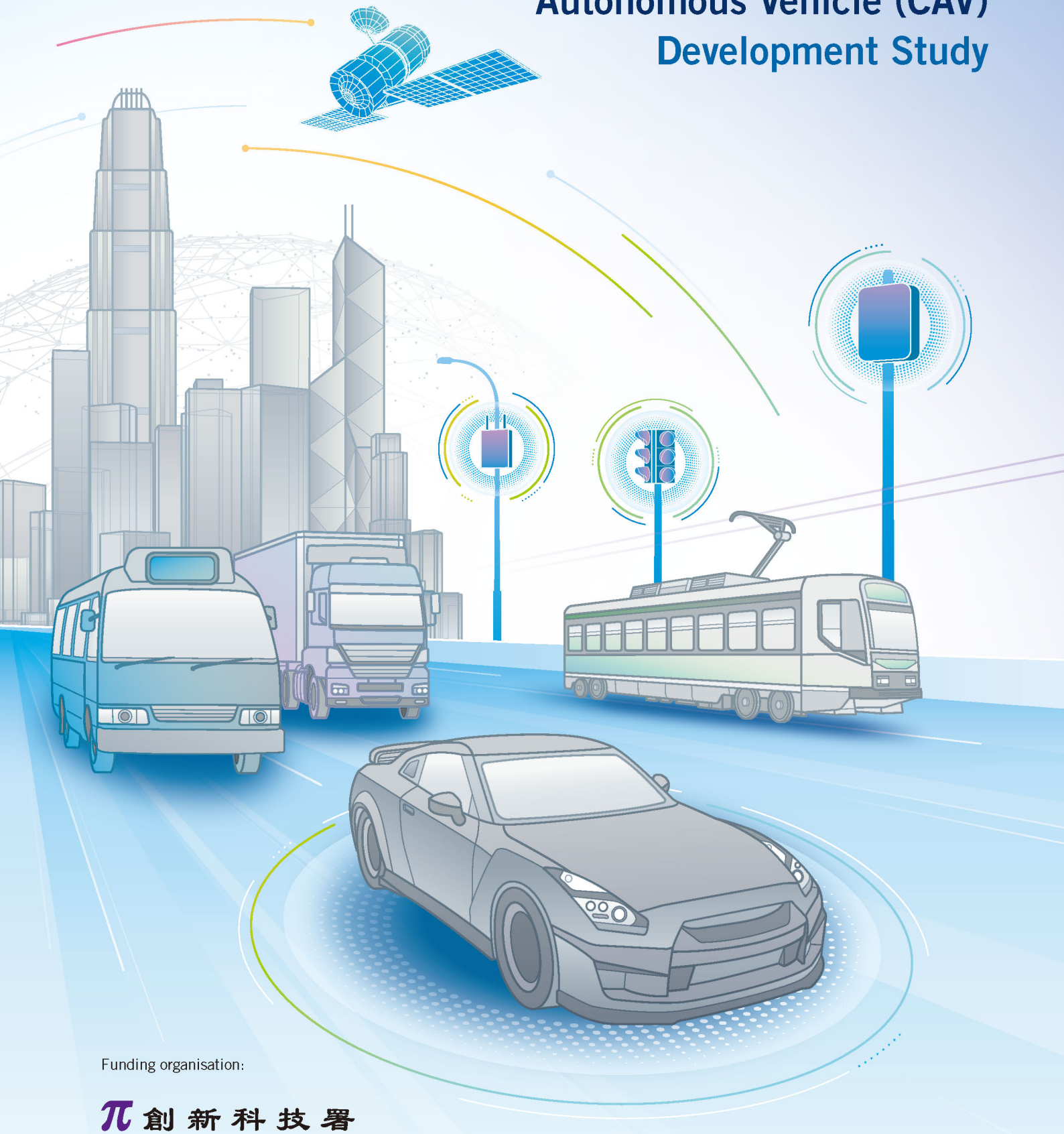
Hong Kong Connected & Autonomous Vehicle (CAV) Development Study



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EXECUTIVE SUMMARY

In support of Hong Kong's smart city agenda, the government revised and introduced regulations related to autonomous vehicles last year, aiming to enhance smart mobility and specifically the CAV technology. This initiative further strengthens our positioning as an Innovation & Technology (I&T) hub for the region. Through vehicle-to-everything (V2X) technology, CAV has the potential to revolutionise the transportation sector by enhancing road safety, improving transport and energy efficiency, and uplifting the travel experience of local commuters.

Anchoring on a set of key ecosystem enablers, covering policy and regulations, infrastructure, R&D capabilities, supply of talent, and access to funding, this report extensively examines the key success factors of industry-leading countries, namely Korea, the Netherlands, Singapore, the United Kingdom and the United States for informing best practices for Hong Kong. Through market insights and comprehensive analysis, we gain deep understanding of the unique landscape of Mainland China, the nine cities of the Greater Bay Area (GBA), and Hong Kong. This assessment aims to assess the current state, identify key challenges, and explore emerging opportunities, thus establishing clear development directions for CAV technology in Hong Kong.

By embracing new opportunities, through enhancing the foundation, coordinating and deepening the development, and creating an environment supportive of CAV technologies and its associated markets, Hong Kong is poised to create unstoppable momentum towards an autonomous future, unlocking its tremendous potential as a leading smart city in the world.

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SECTION 1

CAV Introduction

INTRODUCTION

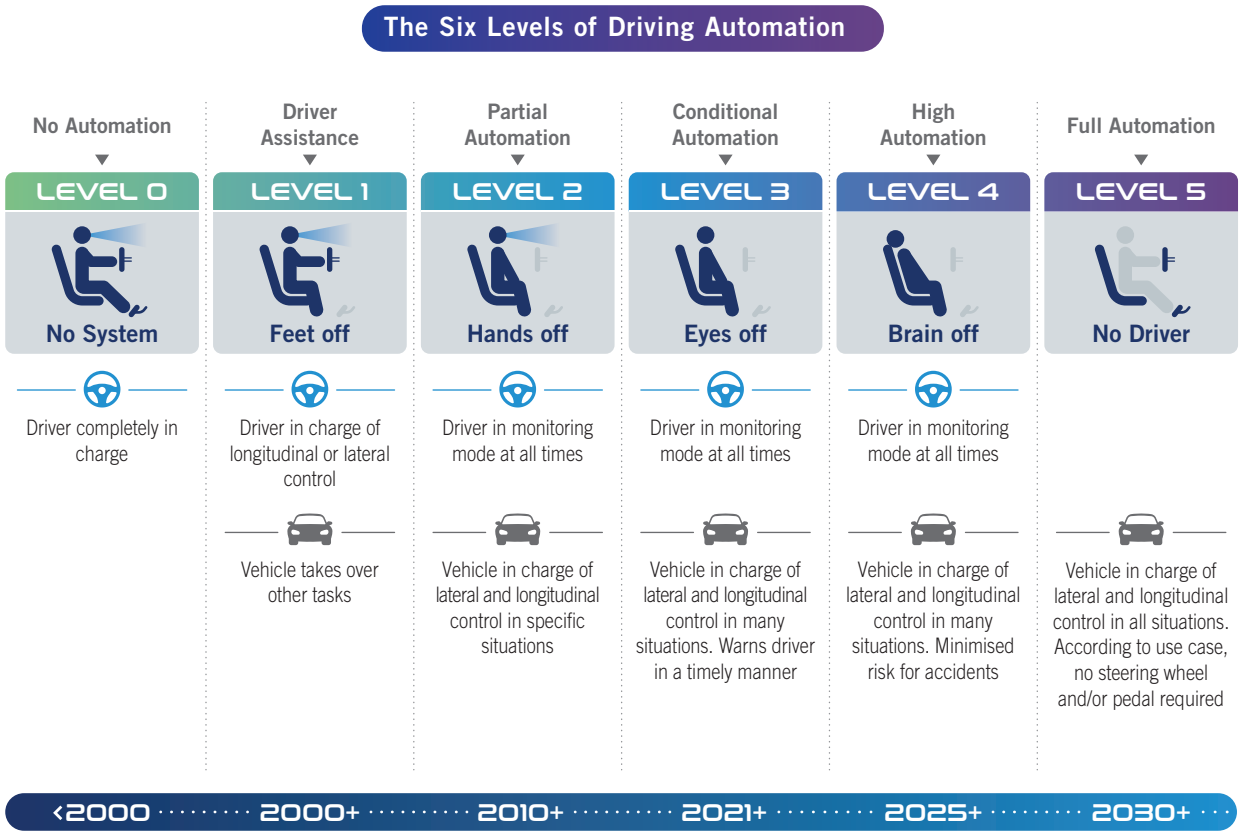
Background

With the Legislative Council's approval of the Road Traffic (Amendment) (Autonomous Vehicles) Bill last year, along with the newly enacted subsidiary legislation, the Road Traffic (Autonomous Vehicles) Regulations, CAV is set to play a crucial role in revolutionising our transportation system. Hong Kong offers a dynamic business environment that encourages collaboration and fosters academic and research excellence, supporting the city's transition into the smart mobility era. Ample funding opportunities are also available to drive practical applications and commercialisation. Coupled with Hong Kong's ambition to develop a robust regulatory framework and smart infrastructure, and its strategic position as the gateway to the GBA and China, Hong Kong is well-positioned to leverage CAV to create a safer, smarter and greener travel experience for all.

Definition

The concept of CAV can be broken down into two components: connected vehicles (CV) and autonomous vehicles (AV). CV are equipped with internet connectivity and communication devices to connect with other vehicles, infrastructure, and technology[1]. AV, on the other hand, can sense their environment and operate without human involvement[2]. The integration of these two components allows for autonomous technologies to acquire information from connectivity, enabling CAV to replace or assist humans in driving tasks.

The following graphic provides a breakdown of the six levels of vehicle automation that were defined by the Society of Automotive Engineers (SAE)'s International J3016 Standard[3].

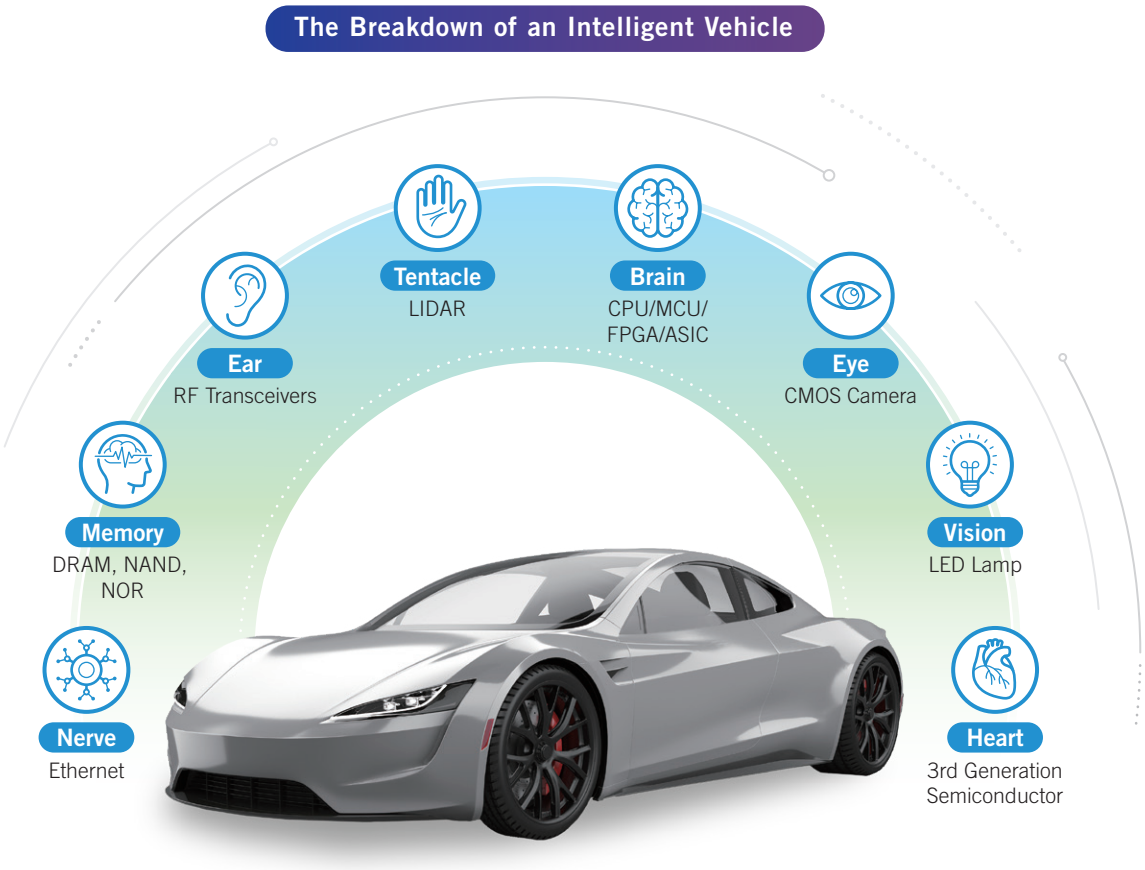


Key Benefits

- **Enhanced road safety:** Driver-assist technologies in AV, such as emergency braking and blind spot monitoring, reduce human driver errors and erratic behaviour, significantly improving road safety[4].
- **Improved transport efficiency:** CAV are programmed to maintain safe and consistent distances between vehicles, minimising stop-and-go waves and reducing road congestion.
- **Environmental sustainability gains:** CAV systems optimise fuel consumption and reduce greenhouse gas emissions by minimising needless idling and fuel wastage caused by road congestion.
- **Increased productivity:** With high levels of automation, AV relieve humans from driving tasks. Occupants can utilise their time and attention for other tasks while the vehicle drives autonomously.
- **Better access to transportation:** CAV integration empowers disabled and elderly individuals with increased independence and freedom to travel, enhancing their self-sufficiency and mobility options.

OPERATING MECHANISM

Intelligent Vehicle Composition



The “brain”, “heart”, and “eyes” are the three foundational parts of intelligent vehicles[5]. The central processing unit (CPU) chip constitutes the “brain” of these vehicles, acting as the control centre and possessing strong scheduling, management, and coordination capabilities. The power semiconductors equate the “heart”, as they are inseparable from these vehicles no matter where in the vehicle they are applied. Complementary metal oxide semiconductor (CMOS) camera’s act as the “eyes” of these vehicles, with these cameras aiding automation tasks like identifying blind spots and forward-looking driving.

It is worthwhile to note that CAV are often electric vehicles (EVs) due to their superior features compared to gasoline or hybrid-powered counterparts. One significant advantage offered by EVs is stable power supply which is able to provide a reliable and consistent power source for substantiating the high-powered CAV components. Additionally, EVs exhibit low latency and consistent response during acceleration, enabling faster decision-making and manoeuvre execution compared to internal combustion engine vehicles.

Enabling Technologies

V2X is an overarching mechanism that enables CV to interact with traffic elements and surroundings. It encompasses four key forms of communications, namely Vehicle-to-vehicle (V2V)[6], Vehicle-to-infrastructure (V2I)[7], Vehicle-to-pedestrian (V2P)[8], and Vehicle-to-network (V2N)[9]

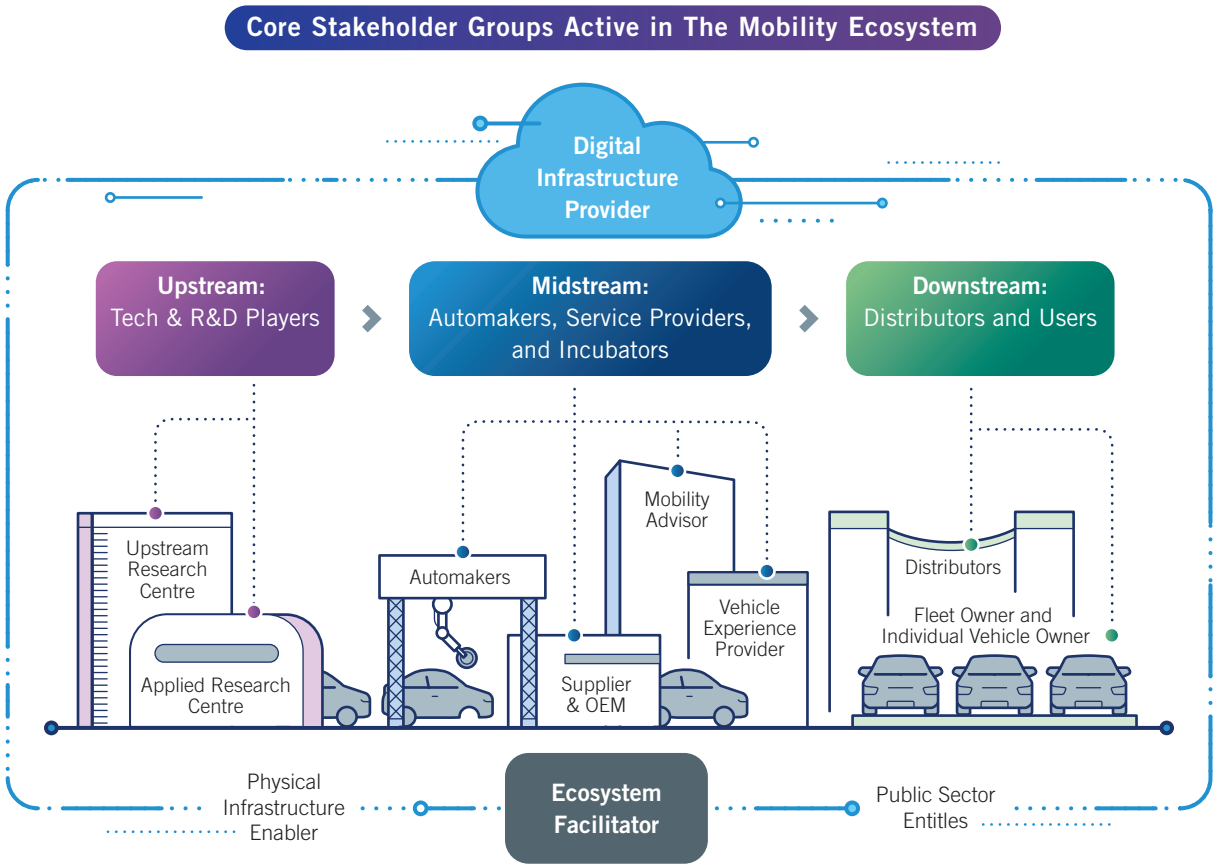
Other key technologies in the field of CAV include environmental perception technology, precise perception technology, high-definition mapping technology, path planning technology and X-by-wire technology.

Ways of Operating

The operating mechanism[10] of a CAV can be broken down into three key stages:

- **First stage – Perception:** The CAV utilises integrated sensors, such as radar systems (e.g. LIDAR) and vision systems (e.g. cameras), to collect data from the surrounding environment, including the roadside and traffic conditions.
- **Second stage – Decision-making**: The collected data is processed by in-vehicle computing programmes and algorithms, enabling the CAV to make intelligent decisions. These decisions are then converted into vehicle behaviour through the execution module.
- **Third stage – Control Execution**: This stage involves precise vehicle motion control and computer-human interactions. Control signals are generated for various actuators, including the motor, accelerator, and brakes, to execute the desired vehicle actions.

Ecological Panorama



The CAV value chain can be categorised into three key streams:

Upstream: R&D & Prototyping

The upstream segment of the CAV value chain[11] primarily concentrates on R&D, testing, and the production of automotive and technological components. Global automaker brands heavily invest in R&D centres to discover proprietary CAV technologies, upgrade products, and gain a competitive advantage in the booming CAV industry.

- **Technology and R&D players:** In the upstream segment, various players, including universities and government-funded research centres, foster innovation through R&D. They drive the advancement and discovery of proprietary technologies and systems for CAV, with universities focusing on theoretical concepts and applied research centres developing practical solutions for specific challenges.

Midstream: Prototyping, Testing & Manufacturing

The midstream of the value chain focuses on vehicle assembly and technical services at a central assembly plant. With the rise of electric vehicles (EV) and the growing CAV manufacturing sector, Original Brand Manufacturers (OBMs) and Original Equipment Manufacturers (OEMs) are striving to capitalise on the emerging market opportunities in this space.

- **Automotive suppliers & manufacturers:** These players in the ecosystem utilise R&D findings

and data to design, produce, and sell CAV and related solutions. Key examples include OEMs (original equipment manufacturers), tier 1 and tier 2 suppliers. OEMs, in particular, play a critical role as they serve as the final integrators, centralising all hardware and software. Additionally, service providers contribute to the transition from vehicle manufacturing to mobility services.

- **Service providers:** Service providers offer value-added services to enhance the user and in-transit vehicle experience. They can be categorised as mobility advisors and vehicle experience providers. Mobility advisors include navigation service providers, maintenance middlemen, and intelligent transport system operators. Meanwhile, vehicle experience providers encompass entertainment equipment providers and other services aimed at enhancing the overall vehicle experience.

Downstream: Commercialisation

The downstream segment of the CAV value chain focuses on commercialisation, sales of CAV, and supplementary value-adding services to end consumers. As EV gain popularity and technological advancements reshape the automobile and mobility landscape, this segment is projected to experience growth.

- **Distributors and wholesalers:** These players in the ecosystem manage the distribution and logistics of key parts and components, facilitating the flow between suppliers, manufacturers, and/or retailers.

- **Fleet owners:** These players either utilise CAV for their own transportation needs or provide them as a service to third parties. Examples include ride-sharing companies and carrier operators.

- **Drivers:** Despite advancements, drivers still play a prominent role in the ecosystem. Current AV laws require a safety driver to be present in all CAV, ensuring safety and compliance.

- **Passengers:** Mass roll-out and commercialisation of CAV heavily rely on passenger acceptance. Safety concerns need to be addressed to generate demand among consumers.

Facilitators also play a vital role in driving the development of the highly vertically integrated CAV industry value chain, ensuring a conducive environment for testing, deployment, and policy support. Physical infrastructure enablers, digital infrastructure providers, and public sector entities all contribute to the growth and advancement of CAV technologies.

SECTION 2

Global Landscape

In the global landscape section, five benchmark countries with similarities in geographical features and CAV industry development stage to Hong Kong are analysed. These countries possess world-leading industry practices that Hong Kong can learn from and extract best practices and lessons.

United States of America

OVERVIEW

Population Density (per km2)	Auto. Market Size (USD billion)	EV Penetration
37	104.1	8.6%

CAV Plan

- Autonomous Vehicles Comprehensive Plan (2021)Autonomous Vehicles Comprehensive Plan (2021)
- Build Back Better Agenda & Bipartisan Infrastructure Deal (2021)

CAV Progress

- **Level 3** automation is applicable dependent on state regulations trending towards **level 4** with private testing programs being conducted
- AV are deployed in areas such as public transport and military defence

United Kingdom

OVERVIEW

Population Density (per km2)	Auto. Market Size (USD billion)	EV Penetration
280	16.9	26%

CAV Plan

- Connected & Autonomous Mobility 2025 (2022)
- Zero Emission Vehicle Mandate (2023)

CAV Progress

- **Level 3** automation authorised for public roads in 2021 moving towards **level 4** with an autonomous bus serving passengers in 2023
- AV are deployed in areas like logistics and public transport

LEADING CAV COUNTRIES AT A GLANCE

The Netherlands

OVERVIEW

Population Density (per km2)	Auto. Market Size (USD billion)	EV Penetration
522	4	8.2%

CAV Plan

- Declaration of Amsterdam (2016)

CAV Progress

- Authorised **Level 3** AVs to operate under specified conditions with **Level 4** automation surfacing, for example with the country's first ever L4 shunting locomotive test
- AV are deployed in areas such as farming, tourism, and public transport

Singapore

OVERVIEW

Population Density (per km2)	Auto. Market Size (USD billion)	EV Penetration
8,592	5	1.4%

CAV Plan

- Smart Mobility 2030 (2014)
- LTA's "Singapore Autonomous Vehicle Deployment Roadmap (2017)

CAV Progress

- Allows for **Level 3** automation on public roads and have since launched the first **Level 4** automation ride-sharing service
- AV are deployed in areas such as private ride-hailing and public transport

Korea

OVERVIEW

Population Density (per km2)	Auto. Market Size (USD billion)	EV Penetration
503	41	10.8%

CAV Plan

- Mobility Innovation Roadmap (2022)

CAV Progress

- Allows for **Level 3** AV to operate on public roads as well as the government setting up safety and insurance standards to allow for **Level 4** automation in 2024
- AV are deployed in areas such as logistics and public transport

COUNTRY PROFILE

KOREA

KEY COUNTRY STATISTICS

Land Area (Square Kilometres)[12]
100,339

Population (Million)[13]
51.8

Population Density (per Km²)
516

GDP 2022 (USD Trillion)[14]
1.67

GDP (2019-2022)
1.2%

EV Penetration (2023)[15]
10.8%

Country Overview

Korea is a dynamic and technologically advanced nation with a thriving manufacturing industry at its core. Korea's key economic drivers revolve around its robust manufacturing industry, particularly in the fields of automobiles, electronics and shipbuilding. The country's commitment to innovation, infrastructure development, and skilled workforce have played a pivotal role in driving its economic growth.

Automotive Industry Development

Korea's automotive industry has been a significant contributor to its economic growth and global reputation. In 2023, the automotive industry was valued at USD 41 billion[16]. The country's automotive manufacturers, such as Hyundai and Kia have established themselves as key global players[17].With a focus on innovation and quality, Korea automakers have continuously developed and produced technologically advanced vehicles. Their expertise extends to EVs and hybrid technology, further solidifying their position in the industry.

CAV Development Target

Korea first prioritised CAV development as a critical component under its "innovative growth" agenda in 2017. The Korea transport ministry has allocated a budget of USD 164 Million specifically for AV infrastructure in 2017[18]. In addition, Korea introduced the "Mobility Innovation Roadmap" in 2022, aimed at fortifying the country's leadership in the mobility sector. By 2030, Korea aims to establish a comprehensive real-time communication infrastructure covering approximately 110,000 kilometres of national roads. Additionally, Korea has set a target for 50% of all new vehicles to be fully autonomous by 2035.

CAV Development Progress

Korea has made significant strides in the development and deployment of CAV's. Currently, the country allows level 3 AV to operate on public roads[19]. Korea has showcased various use cases of AVs. For instance, Seoul has introduced an electric autonomous bus service along the Cheonggyecheon Stream[20], while Jeju Island offers self-driving tour buses[21]. Kakao Mobility utilises AVs for cargo transportation[22], and Hyundai successfully completed the country's first autonomous truck highway journey[23]. Additionally, Daedong has developed Korea's first self-driving tractor[24]. Furthermore, the government has actively engaged in public education to enhance consumer acceptance of AV[25]. This has resulted in a positive consumer sentiment towards AV, with 74% of consumers expressing confidence in riding government-certified AV[26].

CAV Development Initiatives

Policy and Regulation

The Korean government has supported CAV development by establishing safety standards and insurance systems to ensure secure and responsible deployment.

- The Ministry of Land, Infrastructure and Transport (MOLIT) in Korea has published guidelines to address ethical, cybersecurity, and safety considerations in the production of level 4 AV. The country is working towards setting safety standards and implementing an insurance system for the deployment of level 4 AV by 2024, prioritising safety and privacy in AV operations[27].
- The "Amendment to the Compensation Guarantee Act" provides a liability framework for Level 3 self-driving car accidents[28]. It establishes that the vehicle owner's insurance covers damages initially, with the option for the insurance company to seek indemnification from the manufacturer for vehicle defects.

Infrastructure

Korea's smart road infrastructure, and extensive 5G network coverage provide crucial infrastructure for CAV testing, advancing the development of the sector.

- Seoul City has invested in smart road infrastructure by deploying the V2X system in around 2,000 buses operating in Sangam Digital Media City and Seoul City's expressways. This deployment enables Seoul City to offer an advanced public transport system that intelligently alerts drivers about pedestrian collisions and provides warnings about road and weather conditions[29], enhancing overall safety and efficiency.
- Korea leads in 5G coverage, with over 90% of urban areas covered, surpassing the US and Japan. SK Telecom plays a significant role in Seoul's C-ITS project, deploying 2,000 5G terminals on buses and taxis and operating a dedicated 5G control centre for safety information transmission.

R&D Capabilities

Korea strengthens its CAV-related R&D capabilities by developing dedicated testbeds and partnering with industry leaders and research institutions.

- Developed dedicated testbeds for AV testing, including K-City, a 320,000 square meter-wide autonomous testbed in Hwaseong, the Sangam test bed in Seoul capable of 5G testing, an autonomous shuttle testbed in Pan-gyo's Techno Valley, a commercial vehicle testbed in Gunsan, and a town-style test bed in Daegu[30].

- The Korea Advanced Institute of Science & Technology (KAIST) partnered with Hyundai to co-develop high-speed autonomous driving technology[31], while the Korea Automotive Technology Institute (KATECH) partnered with SwRI for autonomous driving technology development[32].
- Khalifa University of Science and Technology and KAIST jointly launched the Khalifa University-KAIST Joint Research Centre in Abu Dhabi, focusing on key topics including “Smart Transportation”[33].

Supply of Talent

Korea fosters smart mobility development through specialised universities programmes

- Korea Aerospace University has established the Department of Autonomous Vehicle Engineering[34] to train professionals for the AI and autonomous driving industries. Additionally, Pyeongtaek University offers specialised programmes on smart mobility[35].

Access to Funding

Korea provides extensive funding support through grants, subsidies, and a vibrant venture capital ecosystem

- The MOLIT established the “Land Transportation Innovation Fund” in 2020[36], providing grants and subsidies to small and medium-sized enterprises engaged in AV and intelligent transport systems activities.
- Korea’s vibrant venture capital ecosystem has attracted significant funding for CAV development[37]. The country's Information and Communication Technology (ICT) service sector, in particular, receives significant venture capital investments, highlighting the focus on fostering technological advancements and entrepreneurship in Korea[38].

THE NETHERLANDS

KEY COUNTRY STATISTICS

Land Area (Square Kilometres)[39]
41,543

Population (Million)[40]
17.6

Population Density (per Km²)
424

GDP 2022 (USD Trillion)[41]
10.0

GDP (2019-2022)
2.9%

EV Penetration (2023)[42]
8.2%

Country Overview

The Netherlands is renowned for its prosperous and open economy. Key economic pillars behind the Netherland's growth include trading and logistics, agriculture, energy, and manufacturing. Due to its strategic location, the Netherlands has become an attractive destination for international businesses seeking to expand their operations and leverage the favourable business environment.

Automotive Industry Development

The Dutch automotive market has experienced an overall decline, whereby the automotive manufacturing industry generated a total revenue of USD 4.0 billion in 2022, a negative CAGR of -3.1% between 2019 and 2022[43]. Notable players in the industry includes DAF and Nedcar. Meanwhile, the EV market stands out as a thriving market segment, with an annual CAGR of 10%[44]. The success of the EV market is driven by the industry's strong emphasis on sustainability, widespread EV adoption, and a robust charging infrastructure.

CAV Development Target

The Netherlands have embraced the potential of CAV for better road capacity utilisation, safer traffic management, and environmental preservation[45]. Through the "Declaration of Amsterdam", focusing on cooperation in the CAV field, the country aims to remove barriers and prepare for the widespread adoption of AV across Europe[46]. While specific CAV development targets are yet to be publicly announced, the Netherlands is actively striving to position itself as a leading country for testing AV and Intelligent Transport Systems (ITS).

CAV Development Progress

The Council of Ministers first approved driverless vehicle road testing in 2015[47]. In July 2022, level 3 autonomous cars were authorised to operate under specified conditions[48]. AV in the Netherlands are primarily revolutionising the transportation, leisure, and agriculture industry. For example, electric driverless shuttles[49] and self-driving minibuses[50] being tested, autonomous ferries are being proposed to improve access to tourist destinations[51], and Smart Agri Technology is leveraging autonomous robots for farming[52]. The Dutch population has demonstrated a higher acceptance of AV compared to other EU countries, solidifying the Netherlands' position as a market leader in the CAV industry[53].

CAV Development Initiatives

Policy and Regulation

The Netherlands government has actively supported CAV development by implementing progressive regulations and fostering public-private partnerships.

- Regulations facilitating safe AV testing have been implemented, including the "Experimenteerwet zelfrijdende auto"[54] allowing AV testing on public roads without a driver present, but with remote monitoring required. Additionally, a rigorous five-step assessment process[55] has been established to thoroughly evaluate AV operations on public roads, ensuring the safety of testing.
- The Dutch Autonomous Vehicle Initiative (DAVI) has been launched through a public-private partnership involving the Netherlands Vehicle Authority, TU Delft, Connekt, and TNO. DAVI focuses on researching and demonstrating high-level AV on public roads while prioritising human safety[56].

Infrastructure

The Netherlands government has prioritised enhancing their infrastructure by taking proactive measures to enhance connectivity and support EV transition.

- The Dutch National Inspectorate for Digital Infrastructure (RDI) reserved two 50MHz blocks specifically for enterprise use, enabling companies to construct their own 5G networks to facilitate the control of smart devices. The 3.5GHz auction will contribute to the enhancement of 5G services and infrastructure in Netherlands[57].
- The Netherlands has invested in smart traffic management systems, installing intelligent traffic control devices (iVRIs) in traffic lights. These iVRIs enable communication between vehicles and traffic lights through smartphone apps, optimising green times and reducing traffic stops. Over 700 smart traffic lights are currently operational in the country[58].
- The Netherlands is a global leader in the development of EV charging network, boasting 111,721 public charging points as of 2022.

R&D Capabilities

The Netherlands actively fosters R&D in smart mobility, providing cutting-edge testing facilities to improve CAV capabilities.

- The RDW Test Centre offers advanced testing facilities for AV, including sound measurements, braking system tests, and steering equipment tests. It also provides inspection services and issues national and international approval certificates (EU and United Nations Economic Commission for Europe)[59].

Supply of Talent

The Netherlands is committed to nurturing talent in the CAV industry. This is achieved through the establishment of specialised CAV research hubs.

- The Automotive Campus in Helmond[60] serves as a collaborative research hub for the automotive industry, fostering talent development and collaboration among businesses, knowledge institutes, and students. The campus offers comprehensive facilities for both virtual and real-life testing, providing opportunities for hands-on experience in the field.
- Tailored CAV programmes at Eindhoven University of Technology (TU/e) provide a comprehensive range of automotive education. The Honours Bachelor programme offers specialised tracks in AV, empowering students to become skilled professionals capable of driving innovation in the CAV industry[61]. Through real-life projects and collaborations with industry leaders and research institutes, students gain practical experience and develop the expertise needed to excel in the dynamic field of CAV.

Access to Funding

The Netherlands have established specific funds and programmes to showcase their commitment to fund the development and advancement of smart mobility initiatives.

- The Netherlands has established various innovation funds and programmes to advance smart mobility. The “Digital Infrastructure for Future-Proof Mobility (DITM)” project[62] has received a government grant of USD 35.4 million, focusing on developing a future-proof, safe, and cyber-secure digital infrastructure system. The “Smart Mobility Programme”[63] in Amsterdam has secured an annual funding of approximately USD 4.1 million, supporting research on self-driving vehicles and exploring the impacts of autonomous transport on accessibility, area development, and traffic safety.

SINGAPORE

KEY COUNTRY STATISTICS

Land Area (Square Kilometres)[64]
734.3

Population (Million)[65]
5.5

Population Density (per Km²)
8,592

GDP 2022 (USD Trillion)[66]
644

GDP (2019-2022)
2.3%

EV Penetration (2023)[67]
1.4%

Country Overview

With a land area of 734.3 square kilometres and a population of 5.5 million, Singapore is known as one of the most densely populated countries in the world, with land use for roads accounts for approximately 12% of Singapore's total land area. By 2030, Singapore's population is projected to reach 6.9 million, hence the topic of urban sustainability and transportation efficiency has always been at the top of the agenda for the Singapore government. Economically, Singapore rests on several pillars that have collectively contributed towards their status as a global financial and business hub, including finance, trading, manufacturing and technology.

Automotive Industry Development

The Singaporean automotive market has stagnated at a market size of USD 4.8 billion, with a negative CAGR of -0.2% from 2019 to 2023. This decline can be attributed to the high costs associated with vehicle entitlement as Singaporeans have to pay a hefty USD 115,000[68] right-to-own premium before purchasing vehicles. Meanwhile, the government is encouraging EV adoption with favourable tax schemes, resulting in a surge in EV adoption from 4% in 2021 to 13% in 2023 Q1. In terms of market share, Toyota has dominated the Singaporean market in 2022, followed by Mercedes-Benz and BMW[69]. The government's main strategic focus is to enhance sustainability and liveability through smart mobility initiatives, aiming to position the nation as a leader in the field of CAV.

CAV Development Target

Jointly published by the Singaporean Land Transport Authority (LTA) and Intelligent Transportation Society of Singapore (ITSS) in 2014, the "Smart Mobility 2030"[70] provides strategic leadership, guidance, and support for industry practitioners to launch smart mobility initiatives and programmes. The strategic plan outlines broad strategies and charts key focal areas (informative, interactive, assistive and green mobility) to address key transport problems in a systematic and coordinated manner and cement the foundation for the country to develop its CAV technologies. A three-stage roadmap was outlined in the LTA's "Singapore Autonomous Vehicle Deployment Roadmap"[71] to propel the AV revolution forward. The first stage aims to understand AV technology through trials and pilot programs, as well as cement a comprehensive regulatory framework to support the "Trial" stage. The next stage is known as the "Limited Development" phase, with its primary focus on rolling-out AV and pilot software deployment at the town level, as well as the deployment of utility vehicles (truck, sightseeing bus etc.) on public roads. The third stage aims to achieve the ultimate objective known as the "Full Operational Deployment" stage, whereby full deployment of AV across all tracks is realised on all Singapore roads.

CAV Development Progress

Singapore industry players have successfully conducted a series of pilot programs over the years, including the first public road testing in July 2015. The country has seen the successful deployment of operational self-driving vehicles in landmarks and institutions such as Garden by the Bay and Nanyang Technological University (NTU)[72]. Commercial autonomous bus services have also been rolled out for the first time in 2021, serving two routes within Singapore Science Park 2 and Jurong Island. From an infrastructural perspective, the government has opened more than 1,000km of public road, representing a tenth of its roads for testing[73] up till 2019. All in all, this forward momentum underscores Singapore's progress towards a CAV-centric landscape.

CAV Development Initiatives

Policy and Regulation

The Singapore government has prioritised the development of CAV technologies in its mobility development ideology since 2013, and has made significant progress in developing policies and frameworks to govern AV deployment.

- Singapore has established the Committee on Autonomous Road Transport for Singapore (CARTS)[74] in 2014 as the dedicated authority for AV. CARTS consists of 17 members from the public sector, planning agencies, international experts, academia, and industry, who regularly engage in discussions and provide feedback on the strategic direction and execution of AV technology and AV-enabled mobility concepts in the country. CARTS plays a vital role in overseeing and guiding the development of AV in Singapore.
- Implemented a five-year AV regulatory sandbox in 2017, which has provided a platform for conducting pilot trials and gathering insights to inform the establishment of permanent regulations for AV systems. This approach allows for the adjustment of road traffic regulations based on the learnings derived from these trials, facilitating the development of effective and informed regulations for AV in Singapore.

Infrastructure

Government agencies, industry players, and academic institutions in Singapore form taskforces to review mobility challenges and implement transportation system upgrades.

- Introduced a next-generation Electronic Road Pricing (ERP) system, installing new on-board units in approximately one million vehicles. The system offers additional features like roadside parking payment and real-time traffic alerts, supporting the government's goal of achieving nationwide V2X communication.
- The LTA has installed roadside sensitive units, including surveillance cameras, CCTV cameras, and dedicated short-range communication beacons. These enhance coverage, accuracy, and support V2X operations by transmitting real-time traffic information to both infrastructure and drivers.
- Singapore aims to strengthen its EV charging infrastructure as part of its vision for all vehicles to run on clean energy by 2040. In 2020, the government announced plans to establish 28,000 charging points in public carparks by 2030[75], supporting the widespread adoption and use of electric vehicles in the country.

R&D Capabilities

Collaborative R&D efforts and a safety-focused AV testing environment in Singapore have driven the rapid development of robust technological capabilities in the country.

- The LTA has developed "Technical Reference 68 for AVs" (TR 68), a set of industrial standards and definitions covering vehicle behaviour, safety, cybersecurity, and vehicular data formats, aiming to foster R&D efficiency and provide guidance for the development and deployment of fully autonomous vehicles
- Launched CETRAN, an enclosed test circuit for AV testing and certification activities. The 1.8-hectare trial zone includes features like a rain simulator and flood zone to comprehensively test AV capabilities under varying weather conditions.

Supply of Talent

Singapore has taken a leading role in nurturing AV talent by implementing proactive initiatives such as educational programmes and job training.

- The LTA and eight industry stakeholders conducted an AV training programme[76] in 2019 for around 100 public bus drivers to acquire the skills needed to handle autonomous buses and potentially transition as safety operators as the need arises.

Access to Funding

Both the government and private investors have been actively supporting local startups and research institutions to extend their research capabilities in the CAV space. Access to funding has also bridged overseas research collaborations, enabling a realisation of global R&D synergies.

- AI Singapore and the Ministry of Defence launched a government-funded research project in 2023, investing USD 15 million to develop AI systems for AV applications[77]. The project involves five research teams comprising industry players and universities from both local and international sources.

UNITED KINGDOM

KEY COUNTRY STATISTICS

Land Area (Square Kilometres)[78]
244,820

Population (Million)[79]
67.8

Population Density (per Km²)
280

GDP 2022 (USD Trillion)[80]
3.07

GDP (2019-2022)
2.4%

EV Penetration (2023)[81]
26%

Country Overview

The United Kingdom (UK) is a highly developed economy where growth has been predominantly spearheaded by their retail, construction, hospitality, healthcare, and finance industries.

Automotive Industry Development

The UK automotive industry, estimated to grow at a CAGR of 6.1%[82] between 2022 to 2029, is responsible for 2.5% of UK's GDP[83]. However, a global parts shortage and supply chain disruptions resulted in 2022 car sales only reaching 1.61 million units, a 30-year low. Volkswagen (131,850 units), Ford (126,826 units) and Audi (110,114 units) were the best-selling brands in the UK in 2022[84]. Meanwhile, the UK EV market prospered in 2022, with EV sales rising 40% YoY and accounting for 16.6% of UK's total vehicle sales. Tesla remain the market leader, but emerging players like MG and Polestar experienced 67% and 79% YoY sales increases[85], highlighting the opportunities presented to capitalise on this rising interest.

CAV Development Target

The UK Government's "Connected & Autonomous Mobility 2025" paper[86] portrays the UK's roadmap for their mobility revolution. The government sets out their vision of deploying AV onto public roads in 2025, with this being enabled by the new "Autonomous Vehicle Bill" aiming to be implemented by 2025. In addition, The British Department of Transport unveiled the "Zero emission vehicle (ZEV) mandate[87]" to accelerate the transition towards an EV world. The mandate requires 80% of new cars sold to be zero emission by 2030, increasing to 100% by 2035.

CAV Development Progress

Level 3 automation has been legalised on public roads since 2021, and the new AV bill announced in the King's Speech on November 2023 will pave the way towards level 4 automation to be operational under certain stipulations[88]. To date, the UK has made significant strides in adopting AV, with various successful pilot programs like the Northeast Consortium's autonomous logistics heavy goods vehicle (HGV)[89] and the UK's first self-driving electric bus service trial at a technology park in Oxfordshire[90]. UK consumer sentiment towards AV remains mixed, with a consumer survey[91] discovering 50% of respondents feel that self-driving cars could make UK roads more dangerous.

CAV Development Initiatives

Policy and Regulation

The UK government have actively liaised with relevant stakeholders to formulate government policy.

- The UK government established the Centre for Connected and Autonomous Vehicles (CCAV)[92] in 2015 as a dedicated governing body. The CCAV serves as a collaborative platform, bringing together technology developers, vehicle manufacturers, suppliers, academia, insurers, and transport bodies to oversee and facilitate the UK's transition towards the era of CAV.
- The UK government has announced plans to introduce an AV bill in 2024[93]. The bill aims to solidify the UK's position as a global leader in AV by establishing a comprehensive legal framework that ensures the safe deployment of AV.

Infrastructure

The UK are refining their infrastructure to best position themselves to conduct rigorous testing, development, and commercialisation of CAV.

- The UK's Department for Culture, Media and Sport (DCMS) has made a significant investment of USD 254 million in the "5G testbeds and trials programme" (5GTT)[94], with the aim of achieving widespread 5G connectivity.
- Advancements in roadway design and infrastructure are being pursued through various projects. Notable initiatives include the Midlands Future Mobility Route connecting Coventry and Birmingham, and the Connected and Autonomous Vehicles: Infrastructure Appraisal Readiness (CAVIAR) project conducted by Highways England, Loughborough University, and Galliford Try[95].

R&D Capabilities

The UK actively fosters and promotes R&D in the smart mobility and CAV space, enabling them to develop their R&D capabilities and become one of the world leaders in the CAV space.

- The UK has invested USD 254 million to develop 6 mature testbeds[96] from Birmingham to London that provide a comprehensive ecosystem for end-to-end testing, including modelling, simulation, testing, and trial deployments in both virtual and physical environments.
- The CCAV has invested in over 90 R&D projects with more than 200 partners[97] to explore, develop and deploying CAV solutions.

Supply of Talent

The UK have worked towards equipping and training their talent to possess all the key traits and knowledge required to thrive in the rapidly evolving CAV industry.

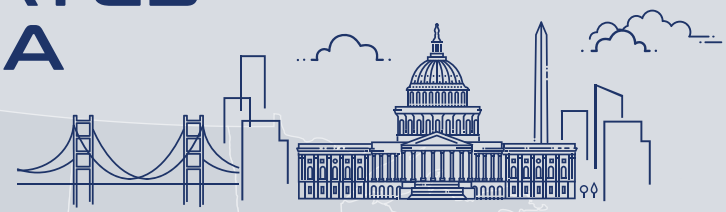
- The “Transport Employment and Skills Taskforce”[98] is a collaboration between industry and government leaders that aims to foster a diverse workforce with transferable skills for the future transport sector.
- The UK has implemented schemes such as the High Potential Global Talent and Innovator Founder Visa[99] to facilitate the relocation of foreign talent.

Access to Funding

There are ample funding opportunities for CAV industry players in both the private and public sector, making the UK a hotspot to secure funding.

- The UK offers ample public funding opportunities to industry players through initiatives such as the "Commercialising Connected and Autonomous Mobility competition"[100] and the "UK Research and Innovation (UKRI) Challenge Fund"[101] to stimulate growth and development in the industry.
- The UK has prioritised funding for AV commercialisation by awarding USD 110 million to seven projects aimed at accelerating the rollout of pioneering AV technology. Examples of the funded projects include a full-sized autonomous bus service in Edinburgh and a self-driving shuttle service in Belfast[102].

UNITED STATES OF AMERICA



KEY COUNTRY STATISTICS

Land Area (Square Kilometres)[103]
9,834,000

Population (Million)[104]
340.7

Population Density (per Km²)
37

GDP 2022 (USD Trillion)[105]
25.5

GDP (2019-2022)
6.0%

EV Penetration (2023)[106]
8.6%

Country Overview

The United States (US) is the world's most developed economy that has built themselves into a leading global finance and research hub. Healthcare, manufacturing, finance, real estate, and technological services are the major economic pillars driving US growth.

Automotive Industry Development

The US automotive industry is a mainstay of their economy, historically contributing 3-3.5% to US's GDP[107]. However, tight inventories, supply chain disruptions, and lagging pandemic effects resulted in a significant decline in annual sales, with only 13.9 million units sold in 2022. This figure represents the lowest sales volume recorded since 2011. Ford, Toyota, and Chevrolet were the three market leaders, with unit sales of approximately 1.768 million, 1.766 million, and 1.5 million respectively[108]. Conversely, the US EV market maintained its upwards momentum in 2022 by selling more than 807,000 EV, a 3.2% YoY increase. Tesla are unequivocally the market leader, but other players are emerging, with Ford and Hyundai selling 61,575 and 58,028 EVs in 2022 respectively[109].

CAV Development Target

As part of the "Build Back Better Agenda & Bipartisan Infrastructure Deal"[110] in 2021, Biden signed an executive order targeting 50% of all new vehicles sold in 2030 to be zero emission vehicles. In addition, the infrastructure deal invests USD 7.5 billion in EV charging, USD 10 billion in clean transportation, and USD 7 billion in EV battery components, critical minerals, and materials. In the same year, the US Department of Transportation Autonomous Vehicles Comprehensive Plan[111] outlined their key goals of promoting collaboration and transparency, modernising the regulatory environment, and preparing the transportation system for the AV revolution.

CAV Development Progress

Currently, level 3 automation is operatable on US public roads dependent on state regulations[112] and the US is home to 300+ innovative AV startups[113], positioning them as a leading CAV nation. AV are being increasingly adopted in the US, with autonomous shuttle services and robotaxis in California[114] as well as US government affiliates like the Department of Defence testing military deployment AV[115]. Automakers have mostly deployed a cautionary approach of waiting for a regulatory framework before launching their AV services, as there have been numerous accidents throughout the country, most notably a fatal accident in Arizona in 2018 involving a ride hailing company[116]. Furthermore, a US mobility confidence study[117] noted a low US consumer AV readiness index score, and 76% of respondents stating they need more information on how autonomous driving technology meets government standards before trusting AV.

CAV Development Initiatives

Policy and Regulation

The US are focused on regulatory framework development through forming initiatives with private stakeholders and statements of intent prioritising AV policy development.

- Efforts are underway to establish a comprehensive AV regulatory framework, advocated by lawmakers as of July 2023. The primary objective is to define standards and liabilities for automakers.
- Public-private partnerships, such as the AV policy initiative with Harvard Kennedy School[118] and the "Autonomous Vehicle Transparency and Engagement for Safe Testing" initiative by the National Highway Transport Safety Administration[119], enhance policymakers' capacity, address social consequences, and ensure safe development and integration of AV.

Infrastructure

The Bipartisan Infrastructure Deal[120] outlines the key infrastructure areas the US aims to strengthen their region's infrastructure.

- To achieve zero-emission mobility, substantial investments are being made. An investment of USD 7.5 billion has been pledged to build a nationwide network of 500,000 EV chargers, while USD 89 billion is dedicated to replacing deficient vehicles with zero-emission alternatives. Additionally, USD 65 billion has been allocated to upgrade power infrastructure, particularly through the development of clean energy transmission grids in the US.
- USD 110 billion funding has been pledged to repair and rebuild public roads and highways in the US, with the aim of accommodating the development of AV.

R&D Capabilities

The US are the forefront of R&D, equipping market players with the R&D capabilities required to spearhead the US's development in the CAV space.

- The US Department of Commerce's National Institute of Standards and Technology has established an AV programme[121]. This programme brings together stakeholders to collaborate on deploying AV technologies, enhancing system interaction capabilities, and addressing unforeseen challenges through workshops and conferences.

- The Intelligent Transportation Systems Joint Program Office has developed a cutting-edge connected vehicle testbed[122]. This testbed features 50 roadside equipment units, advanced connectivity technology, and a team of highly skilled professionals to facilitate the execution of complex scenario live tests for AV.

Supply of Talent

Alongside their wealth of renowned academic institutions, industry player and academic institutions collaborations further strengthen their talent pool.

- Academia-industry collaborations in the AV field include a partnership between Pima Community College and TuSimple, the first public US AV company, to establish a certificate programme[123] for training AV truck drivers. Additionally, "MIT's Driverless"[124] serves as a hub of practical autonomy at MIT where students gain practical knowledge of deploying autonomous software and connect with industry partners.

Access to Funding

Public funding is currently a more attractive avenue for US industry players as private funding raised has slowed down the last few years.

- The US Department of Transport offers funding opportunities such as the "Autonomous Driving System Demonstration Grants"[125] for projects focused on testing the safe integration of autonomous driving on US roads. Additionally, the newly established "Strengthening Mobility and Revolutionising Transportation" programme[126] provides grants to public sector agencies conducting projects that advance smart technologies and systems.
- Venture capital funding in the US AV sector has declined in recent years. While the sector initially attracted substantial investment due to its profit potential, investor confidence has waned due to safety concerns arising from accidents and weak market sentiment. As a result, the number of deals in the sector has been steadily decreasing, with only 139 deals completed in 2023, marking the lowest figure in the past six years[127].

KEY LESSONS LEARNED

Policy and Regulation

Establish a dedicated CAV governing body

Leading CAV nations like the UK and Singapore have established governing bodies composed of industry practitioners, regulators, and academia experts. These bodies monitor the CAV landscape, raising consumer awareness, fostering investor confidence, and ensuring industry development stays on track.

Encourage consistent amendment and modernisation of regulatory framework

A robust regulatory framework is vital for the dynamic CAV market. Without it, firms may delay technology rollouts, and public safety concerns may increase. A regulatory sandbox, such as Singapore's 5-year AV sandbox, enables innovation. Clear guidelines on insurance and liability must be established. For instance, Korea's "Amendment to the Compensation Guarantee Act" sets a notable example by clarifying liabilities for L3 automation car accidents.

Infrastructure

Construction of a physical infrastructure capable of supporting CAV deployment

A well-maintained physical infrastructure is a key pillar facilitating CAV testing and deployment. Leading CAV regions, such as the USA and the Netherlands, are investing significantly in road infrastructure to support CAV development. Smart physical infrastructures like traffic light sensors and roadside units (RSU) can enhance safety by providing CAV with information on blind spots, pedestrians, and traffic congestion. Additionally, a well-maintained road infrastructure can ensure accurate high-definition mapping, which is essential for route selection in AV systems.

Development of a highly connective digital infrastructure

A reliable digital infrastructure is crucial for CAV development. Countries like the US, UK, Netherlands, and Korea have heavily invested in expanding their 5G network coverage to support CAV advancements. 5G enables V2X communication, enhancing collision avoidance and hazard-warning capabilities. A robust digital infrastructure can enhance vehicle communications, AV decision-making, and enables new applications, leading to improved road safety, consumer satisfaction, and traffic management.

R&D Capabilities

Comprehensive testbeds to accelerate CAV development

Comprehensive testbeds drive CAV deployment by providing rigorous end-to-end testing. The UK, for example, has invested USD 254 million in 6 testbeds that offer comprehensive physical and virtual CAV testing. These testbeds simulating road and traffic conditions can hugely strengthen CAV development, as the data extracted serves to modify and fortify AV.

- **Cross-border and value chain R&D collaborations**

  Cross-border partnerships, like Korea's KAIST and Khalifa University of Science and Technology's joint AV and EV research centre in Abu Dhabi, can foster expertise and resource exchange, generating synergies and mutual benefits. Collaboration across value chain segments can strengthen the entire CAV ecosystem, enabling stakeholders to leverage each other's expertise and optimise R&D efficiency and value.

Supply of Talent

- **Public-private collaborations to nurture talent**

  Developing modern training solutions and equipping talent with the right skills and knowledge is crucial for the evolving CAV industry. Public-private partnerships, like the UK's Transport Employment and Skills Taskforce, can accelerate talent recognition, provide training, and deploy talent in the public and private sectors.

- **Academia-industry collaborations to broaden talent exposure**

  Academic institutions and market players can collaborate on initiatives like the certificate programme jointly launched by TuSimple and the Pima Community College for training AV truck drivers in the US. Higher-education degrees in CAV can provide both theoretical and practical knowledge to students. Notably, Eindhoven University of Technology (TU/e) in the Netherlands has been offering dedicated automotive degree programmes that foster talent for driving innovation in the CAV industry.

Access to Funding

- **Investor confidence must be regained to maximise private funding**

  The CAV market is still evolving, and the investment atmosphere remains relatively cautious. To instill confidence among investors, governments can introduce or amend regulatory frameworks to define safety requirements and liability. Stronger disclosure of proprietary research by startups and companies can also provide investors with clarity and assurance regarding rigorous testing and safety prioritisation.

- **Provide ample funding opportunities to CAV-enabling industries within the transport ecosystem**

  Ample public funding for CAV projects and CAV-enabling industries is crucial for industry growth. For instance, Korea established the “Land Transportation Innovation Fund” to support SMEs in intelligent transport systems and land transportation. Funding in areas like intelligent transport systems, public transportation mobility, 5G connectivity, and artificial intelligence can accelerate CAV roll-out.

SECTION 3

Local Landscape

CHINA DEVELOPMENT

Country Overview

China stands at the forefront of global innovation and transformation in science and technology, showcasing a unique fusion of traditional manufacturing strength and cutting-edge R&D capabilities. With the support of the central government, China is dedicated to accelerating the development of CAV. Its robust industrial ecosystem, research capabilities, and innovation drive have positioned China as a global leader in the CAV space.

Automotive Industry Development

China has been a global leader in the automotive market, excelling in both sales and production. Since 2014, China has consistently sold over 20 million passenger cars annually. In terms of production, China accounts for 32% of the global total, manufacturing around 82 million vehicles in 2022[128].

A key contributor to China's automotive success is its pragmatic shift towards an EV-oriented market. In response to the government's overarching development directives, both domestic and international OEMs have actively engaged in EV manufacturing since 2018. This concerted effort has propelled China to become the largest EV market worldwide, with a record-breaking 25.6% sales growth in 2022[129]. Furthermore, the EV penetration rate in China has reached an impressive 28%[130].

CAV Development Target

China's robust foundation in EV technology and market maturity has propelled it towards the goal of developing a nationwide intelligent transportation system. Key principles outlined in the "14th Five-Year Plan for Modern Comprehensive Transportation System" (《"十四五"現代綜合交通運輸體系發展規劃》) encompass the following core areas:

Construction of smart infrastructure and 5G-V2X networks:

Expand 5G network coverage progressively and enhance transportation and traffic data transmission through improved coverage, instantaneity, and accuracy

Establishment of a comprehensive regulatory framework and monitoring platform:

Implement a blockchain-based transportation information system to support comprehensive information monitoring

Acceleration of smart highway construction:

Deepen the adoption of Electronic Toll Collection (ETC) and establish intelligent transport infrastructure to facilitate V2X realisation

These core areas reflect China's commitment to building an advanced and integrated intelligent transportation system that encompasses the seamless integration of "people, vehicles, road infrastructure, cloud technologies, and network connectivity".

The table below presents an overview of the development guidelines issued by the Central government to facilitate industry advancements in the field of CAV.

China Smart Mobility Development Guidelines At a Glance

Year of Publication	Publication Name	Issuing Body
2016	Guidelines for the Construction of National Standards System for Connected Vehicle Industry 《國家車聯網產業標準體系建設指南》	Ministry of Industry and Information Technology
2017	Guidelines for the Construction of National Standards System for Connected Vehicle Industry (Electronic Products and Services)《國家車聯網產業標準體系建設指南（電子產品與服務）》	Ministry of Industry and Information Technology
2017	Guidelines for the Construction of National Standards System for Connected Vehicle Industry (Intelligent Cooperative Driving)《國家車聯網產業標準體系建設指南（智慧網聯汽車）》	Ministry of Industry and Information Technology
2018	Guidelines for the Construction of National Standards System for Connected Vehicle Industry (General Requirements)《國家車聯網產業標準體系建設指南（總體要求）》	Ministry of Industry and Information Technology
2019	Guidelines for the Construction of National Standards System for Connected Vehicle Industry (Intelligent Vehicle Management)《國家車聯網產業標準體系建設指南（車輛智慧管理）》	Ministry of Industry and Information Technology
2021	Opinions on Strengthening the Management of Access to Intelligent Connected Vehicle Manufacturers and Products（關於加強智慧網聯汽車生產企業及產品准入管理的意見）	Ministry of Industry and Information Technology
2021	Guidelines for the Construction of National Standards System for Connected Vehicle Industry (Intelligent Transportation Related)《國家車聯網產業標準體系建設指南（智慧交通相關）》	Ministry of Industry and Information Technology
2021	14th Five-Year Plan" for the Development of Modern Comprehensive Transportation System《「十四五」現代綜合交通運輸體系發展規劃》	The State Council of the People's Republic of China
2022	"14th Five-Year Plan" for Technological Innovation in the Transportation Sector（《「十四五」交通領域科技創新規劃》	Ministry of Transport of the People's Republic of China

CAV Development Progress

China's CAV industry has experienced substantial growth and development, establishing itself as one of the global leaders in AV manufacturing. Beijing and Shanghai are at the forefront of commercialisation, with successful autonomous ride-sharing pilots and granted road testing licenses. Additionally, cities like Chongqing, Wuhan, Guangzhou, and Shenzhen have implemented commercial pilot policies for AV[131].

In 2022, the sales of new passenger cars equipped with autonomous driving systems reached 7 million units[132], representing a penetration rate of 23.5% of total car sales that year. Correspondingly, the demand for supplementary products and services related to AV technologies has surged. From January to May 2023, the insurance volume for level 2 or above AV reached 3.1 million units.

CAV Development Initiatives

Policy and Regulation

The Central government is driving CAV development through implementing standardised frameworks, and launching comprehensive test drive regulations.

- The Ministry of Industry and Information Technology implemented the "National V2X Industry Standardisation Blueprint"(《國家車聯網產業標準體系建設指南》)[133] in 2023 to establish standardised guidelines for the CAV industry. This blueprint covers definitions in 40 categories, ensuring consistency in AV and V2X infrastructure testing and interpretation.
- China has implemented a comprehensive and strict CAV road test regulation system, including licensing requirements and guidelines. Applicants must undergo assessments of their organisation's background and AV hardware to obtain the necessary permits[134].

Infrastructure

The government is actively advancing the intelligent road infrastructure for smart mobility advancements.

- In 2020, The State Council of China issued the "New-Energy Vehicle (NEV) Industry Development Plan for 2021-2035 (Guo Ban Fa No. 39 [2020])" (《新能源汽車產業發展規劃(2021-2035年)》(國辦發 [2020] 39號)). The plan aims to accelerate the formulation of wireless communication (C-V2X) standards and enhance intelligent interconnection among traffic signal lights, road signs, and communication facilities. These efforts support the development of V2X and interconnected traffic systems.

R&D Capabilities

The central government has actively collaborated with practitioners and industry stakeholders to enhance the applicability and efficiency of the CAV R&D landscape.

- China has expanded testing zones to include all public road types, including highways, and has allowed testing of "utilities vehicles" like road sweepers. Efforts have been made to improve testing efficiency and reduce burdens on enterprises by eliminating repetitive testing at single locations.
- China has established 40 test demonstration zones nationwide, providing over 15,000 kilometres of permitted test roads. These zones are specifically designed to support the evaluation of extreme driving scenarios. As of 2022, the total test mileage has exceeded 40 million kilometres.

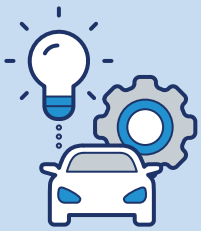
Supply of Talent

China fosters CAV talent through specialised programmes in universities and internal training programmes in companies, nurturing skilled professionals to drive CAV advancements.

- Companies in the CAV industry have implemented internal talent development programmes to train newly hired computer science graduates and recent graduates with limited experience in autonomous driving, enabling them to make significant project contributions within six months of joining the company[135].
- Universities and vocational colleges have created specialised programmes, such as Tsinghua University's Vehicle and Transportation School, Beihang University's Autonomous Driving Program, and Hefei University of Technology's Intelligent Vehicle Engineering program, to meet the growing demand for skilled professionals in the industry.

GBA DEVELOPMENT

Automotive Industry Development



The GBA has emerged as a major automotive hub with a focus on EV and autonomous driving led by cities like Guangzhou and Shenzhen. Guangdong Province, encompassing the GBA cities has made significant progress in growing its automotive industry. In 2022, automobile production in Guangdong Province reached 4.2 million vehicles, representing a year-on-year growth of 22.7% and accounting for 15.1% of the national total.

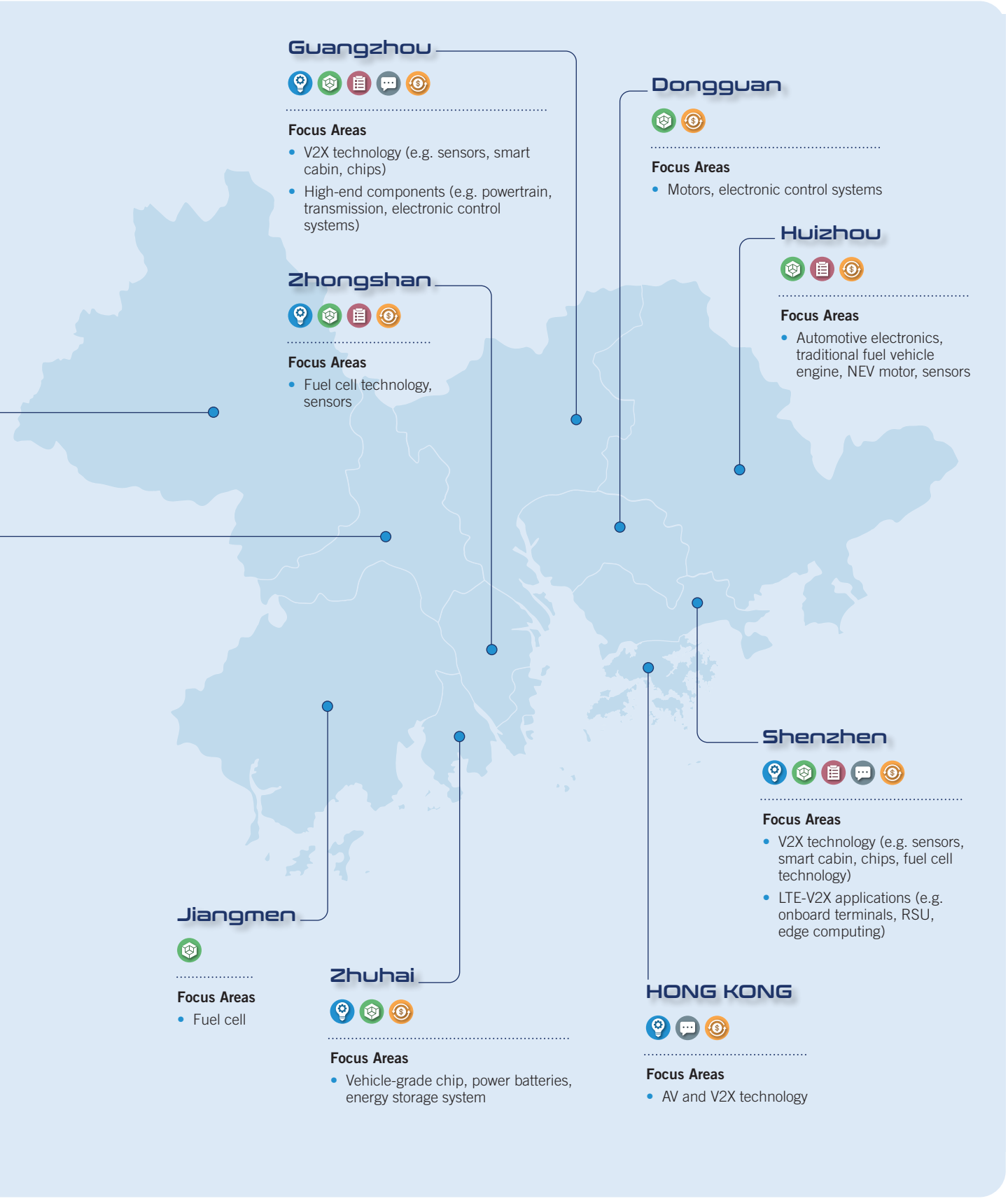
Amongst the GBA cities, Guangzhou holds a prominent position in the automotive industry, particularly in terms of vehicle production and core component manufacturing. Hosting 12 vehicle manufacturing companies and over 1,200 automotive component manufacturing and trading enterprises[136], accounting for over 90% of the province's vehicle production. The city showcases various AV use cases, including Robo-Taxis, autonomous buses, unmanned cargo handling, Robosweepers, Level 4 autonomous minibuses, and unmanned retail services. These deployments demonstrate the city's commitment to embracing AV technology across transportation, logistics, and urban services sectors[137].

Shenzhen is another city with a pioneering force in the field of CAV. In June 2022, the city enacted the "Regulations on the Management of Intelligent Connected Vehicles"(《深圳經濟特區智慧網聯汽車管理條例》)[138], becoming the first in China to establish autonomous driving laws. Furthermore, Shenzhen's inclusion of the intelligent connected vehicle industry in its "20+8" industrial cluster list demonstrates its commitment to accelerating CAV development[139]. With its unique combination of research, design, and manufacturing capabilities, Shenzhen has positioned itself as a leading hub for comprehensive CAV growth and innovation.

Shenzhen leads in autonomous driving demonstrating various AV use cases. Pingshan District features autonomous buses, minibuses, taxis, unmanned delivery, unmanned sanitation and retail routes. Futian showcases L4 autonomous taxis, Longgang tests unmanned postal delivery, Nanshan operates autonomous ride-hailing, and Mawan hosts a 5G+ autonomous port[140]. These deployments highlight Shenzhen's pioneering role in autonomous driving across multiple sectors.

In terms of city positioning, the GBA aims to establish automotive industrial parks for first-tier suppliers in major cities such as Guangzhou, Shenzhen, Foshan, and Zhaoqing. Meanwhile, other cities will develop industrial parks for second and third-tier suppliers, fostering a comprehensive and integrated automotive ecosystem[141].

GBA CITY POSITIONING ACROSS THE AUTOMOTIVE VALUE CHAIN


Guangzhou
Focus Areas
• V2X technology (e.g. sensors, smart cabin, chips)
• High-end components (e.g. powertrain, transmission, electronic control systems)
Dongguan
Focus Areas
• Motors, electronic control systems
Huizhou
Focus Areas
• Automotive electronics, traditional fuel vehicle engine, NEV motor, sensors
Zhongshan
Focus Areas
• Fuel cell technology, sensors
Shenzhen
Focus Areas
• V2X technology (e.g. sensors, smart cabin, chips, fuel cell technology)
• LTE-V2X applications (e.g. onboard terminals, RSU, edge computing)
Jiangmen
Focus Areas
• Fuel cell
Zhuhai
Focus Areas
• Vehicle-grade chip, power batteries, energy storage system
HONG KONG
Focus Areas
• AV and V2X technology

CAV Development Target[141]

The "Guangdong Province Implementation Plan for the Development of Automotive Industry – Strengthen Supply Chain Project" (《廣東省汽車零部件產業"強鏈工程"實施方案》) was issued in 2022. This plan outlines the strategic objectives of Guangdong Province to establish itself as a prominent player in the field of CAV. Key targets include:

Region	Target
Guangdong Province	• Advancing core technologies crucial for connected vehicles • Nurturing industries associated with safety, computing power, and communication infrastructure • Promoting the widespread adoption of automotive chips, focusing on enhancing their supply capacity, design, manufacturing, packaging, and overall application in AV
Guangzhou	• The "Guangzhou's 14th Five-Year Plan for the Innovative Development of Intelligent and New Energy Vehicles"[142] (《廣州市智慧與新能源汽車創新發展"十四五"規劃》) sets forth specific targets for the development of CAV by 2025. The plan aspires to achieve a significant milestone of 80% market share for new vehicles equipped with autonomous driving capabilities (Level 2 and above). It further envisions the gradual commercialisation of level 3 or above AV in restricted areas and the establishment of 800 km of intelligent roads
Shenzhen	• The "Action Plan for Cultivating and Developing the Intelligent Connected Vehicle Industry Cluster in Shenzhen (2022-2025)" (《深圳市培育發展智慧網聯汽車產業集群行動計畫(2022-2025年)》) was issued in 2022. The plan sets a target revenue of USD 31 billion for the CAV industry by 2025[139]. Shenzhen's goal is to establish a leading intelligent connected vehicle public service platform with robust capabilities, seamlessly integrating with smart city infrastructure to cater to diverse travel service needs[143]

CAV Development Initiatives

Policy and Regulation

Guangzhou

- The issuance of the "Guiding Opinions on the Road Testing of Intelligent Connected Vehicles"(《關於智慧網聯汽車道路測試有關工作的指導意見》)[144] in 2018 has established a centralised and standardised management framework, supporting and streamlining the road testing activities of CAV enterprises, enhancing efficiency and effectiveness.
- The Guangzhou government utilises platforms like the Guangzhou International Automobile Exhibition and the Guangzhou Annual Investment Conference to attract investments and encourage the establishment of research and production bases in the city[137].

Shenzhen

- The "Regulations on the Management of Intelligent Connected Vehicles" (《深圳經濟特區智慧網聯汽車管理條例》)[145] were developed drawing insights from leading countries such as the United States, Germany, and Japan. These regulations include provisions on safety notifications, driver takeover obligations, and after-sales service mechanisms, contributing to the responsible and efficient advancement in the industry.
- In 2022, the Shenzhen government enacted comprehensive regulations covering various aspects of CAV operations, including road testing, registration, network security, data protection, traffic violations, and accident handling. This legal framework reduces uncertainty, mitigates legal risks, and provides clear boundaries for innovation and investment in the CAV industry.

Infrastructure

Guangzhou

- Guangzhou has actively deployed 5G networks with over 76,400 base stations as of 2022, ensuring comprehensive coverage throughout the city.
- Guangzhou initiated a large-scale smart road construction project in 2020, focusing on autonomous driving and vehicle-road coordination. The project includes the deployment of 1,318 AI perception devices and 104 V2X roadside communication units at selected intersections and road sections, facilitating efficient testing and deployment of CAV.

Shenzhen

- Shenzhen Traffic Police and Huawei collaborated to develop the "Pengcheng Intelligent Transportation System"[146]. This system incorporates cloud, big data, and AI technologies to enhance traffic management. By 2020, the ITS had been deployed at more than 700 intersections in Shenzhen, addressing ten typical intelligent traffic control scenarios.

R&D Capabilities

Guangzhou

- The city is committed to accelerating R&D efforts by establishing testing grounds in districts like Huangpu, Nansha, Panyu, Huadu, and Haizhu, providing a practical environment to showcase CAV performance[137].

- Guangzhou has also attracted presence of authoritative and reputable testing and R&D platforms such as the Electronic Fifth Institute of the Ministry of Industry and Information Technology, China Automotive Technology and Research Centre South China Base, CVC International, and the Guangdong Institute of Metrology to enhance trust in the reliability and safety of CAV technologies.

Shenzhen

- Shenzhen has been facilitating collaborations between industry players and academic institutions, such as the partnership between City of Light (Shenzhen) Autonomous Driving Co., Ltd. and the Beijing University Shenzhen Graduate School to promote synergy and accelerating technological advancements[147].

- During the Global Intelligent Connected Vehicle Commercialisation and Innovation Forum 2023, 26 companies, including prominent organisations like Shenzhen Urban Transport Planning Centre, BYD and SenseTime, collaboratively established the Shenzhen Intelligent Connected Transportation Association. This association creates a platform for CAV industry players to join forces, set industry standards, and create a world-class ecosystem for driving innovation[148].

Supply of Talent

Guangzhou

- Guangzhou actively creates a supportive environment to attract international technological talents in the CAV ecosystem, as demonstrated by Nansha District Secretary Cai Chaolin's visit to Pony.ai in Silicon Valley and their subsequent relocation of headquarters and establishment of a research institute in Guangzhou[149]. WeRide also established its global headquarters in Guangzhou with strong support from the Guangzhou Municipal government[150].

- The Guangzhou Intelligent Connected and New Energy Vehicle Electronics Industry Development Association provides training and consulting services to CAV enterprises, improving the skills and competence of the industry workforce[151].

Shenzhen

- Shenzhen universities offer practical training and internship collaborations for undergraduate students majoring in Vehicle Engineering and Automotive Service Engineering. Partnering with industry-leading companies like BYD and automotive component manufacturers, these programmes prepare graduates to meet the industry's demand for skilled professionals in the CAV sector.

Access to Funding

Guangzhou

- Guangzhou has established targeted funds to support the automotive industry. Under the "Measures to Support the Stability, Supplementation, and Strengthening of the Automotive and Core Component Industries in Guangzhou"(《廣州市支持汽車及核心零部件產業穩鏈補鏈強鏈的若干措施》)[152], up to USD 77 million is allocated annually for R&D of core components and key technologies by automotive enterprises. Additionally, the Guangzhou Intelligent Connected and New Energy Vehicle Industry Development Fund, with a budget of USD 1.54 billion, primarily supports significant projects in the intelligent connected and new energy vehicle industry chain.

Shenzhen

- The Shenzhen government offers ample financial incentives to stimulate upstream R&D and testing in the CAV industry. This includes ample funding for areas such as V2X communication, perception technologies, high-precision mapping, algorithm design, and reduced testing fees for participants conducting CAV road tests in dedicated test fields[153].

- Shenzhen actively facilitates connections between startups and investors for funding and partnerships within the CAV ecosystem. For instance, the annual 'Shenzhen Investment and Venture Capital Day' serves as a platform for these connections, bringing together startups and prominent domestic and international venture capital firms. The event, held in Pingshan in March 2023, focuses on industries such as automotive, pharmaceutical, and semiconductor, attracting nearly 100 venture capital firms[154].

GBA CAV Development Analysis

GUANGZHOU

Policy and Regulation

- Supportive and standardised road testing framework with the issuance of the "Guiding Opinions on the Road Testing of Intelligent Connected Vehicles"
- Facilitate networking and collaboration opportunities through hosting various conferences
- Increase flexibility in the regulatory framework to further drive deployment and commercialisation of CAV technology

Infrastructure

- Robust 5G network infrastructure ensures a strong and reliable network infrastructure
- Conducive testing environment in Guangzhou attracts industry leaders like Baidu Apollo to establish presence in the city
- Digital infrastructure development, particularly in terms of 5G coverage density, needs to be enhanced to facilitate widespread adoption of CAV

R&D Capabilities

- Presence of authoritative testing and R&D platforms can bring valuable expertise, resources, and credibility to the development and validation of CAV technologies
- Continuous collaboration between industry, academia, and government entities is necessary to drive ongoing research, development, and innovation in the CAV technology sector

Supply of Talent

- Government support for talent attraction such as issuing licenses for remote AV testing and allowing the operation of Robotaxis, attracts talented individuals to relocate to Guangzhou
- Prioritise the acquisition of the necessary skills and knowledge needed to keep up with industry advancements

Access to Funding

- Targeted funding support provided by Guangzhou government drives innovation and fuels the growth of the CAV sector in Guangzhou
- More resources and funding opportunities should be provided to SMEs, while relaxing strict qualification standards, to help them overcome funding challenges

Positive Factors Areas of Improvement

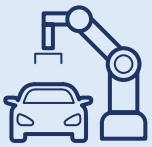
SHENZHEN

Policy and Regulation

- Adoption of best practices by drawing on practices from leading countries such as the US, Germany and Japan
- Consider the development differences between the benchmarked countries and Shenzhen in order to design policies that meet the specific needs of the city

Infrastructure

- Efficient and predictable traffic environment achieved from the implementation of ITS can improve CAV's capabilities for navigation and decision-making
- Coverage of Shenzhen's ITS should be expanded to ensure smooth operation of CAV between areas with and without intelligent traffic control



R&D Capabilities

- Active industry collaboration in Shenzhen demonstrates the city's commitment to fostering a collaborative ecosystem for R&D in the CAV industry
- Influence of Shenzhen Intelligent Networked Transportation Association should be expanded to encourage more business participation

Supply of Talent

- Internships with CAV enterprises offer valuable practical training opportunities for students, allowing them to gain exposure to real-world challenges in the CAV field
- The scope of internship programmes should be expanded to involve students from diverse disciplines, promoting interdisciplinary collaboration and innovation

Access to Funding

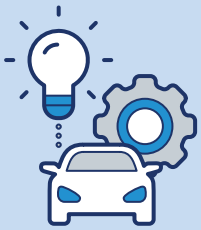
- Sector-specific funds for key CAV technologies available in Shenzhen to foster innovation
- Convenient access to private funds via events like the annual 'Shenzhen Investment and Venture Capital Day' to facilitate connections between startups and investors
- The Shenzhen government should take into account both the upstream and downstream activities in the CAV value chain when allocating funds, aiming to foster a well-rounded industry development
- Encourage VCs to invest in a broader range of CAV fields to support the development and innovation of startup companies

HONG KONG DEVELOPMENT

City Overview

Hong Kong plays a pivotal role in GBA as a global financial hub and a vital link between Mainland China and the international markets. With its robust financial infrastructure, legal system, and extensive international connections, Hong Kong serves as a pivotal business gateway within the GBA, facilitating cross-border investments, trade, and financial services. In line with the "Outline of the Fourteenth Five-Year Plan for the National Economic and Social Development and the Long-Range Objectives Through the Year 2035", the government has been actively promoting cross-disciplinary and cross-jurisdictional collaboration to support Hong Kong's development into an international I&T hub.

Automotive Industry Development



Hong Kong's automotive market possesses a unique blend of cosmopolitan influences and a sophisticated consumer base. Despite its relatively small market size and lower ownership of private vehicles due to the city's heavy reliance on public transportation, the city is characterised by a remarkable adoption of EV due to the government's tax concession on EV purchase. As of September 2023, EVs accounted for over 70% of newly registered passenger vehicles, demonstrating their dominant presence in the market and the substantial progress achieved in promoting their widespread usage in recent years.

The government's comprehensive support, as outlined in the "Hong Kong Roadmap on Popularisation of Electric Vehicles," has played a pivotal role in facilitating this rapid development. Measures such as registration tax concessions, funding for new energy research and development, and the implementation of charging stations[155] have contributed to the remarkable advancement of

EVs. Furthermore, Hong Kong's focus on promoting EV has established a solid foundation for the concurrent development of CAV. This is possible due to the shared technological advancements and infrastructure required for EVs, including charging stations and energy management systems, which can be leveraged to support the future integration and deployment of CAVs in Hong Kong's automotive market.

CAV Development Target

The concept of V2X technology was initially introduced in the "Smart Mobility Roadmap for Hong Kong"[156] by The Transport Department (TD) in 2019. The roadmap envisioned the establishment of a connected transport network system that enables seamless data transmission and communication among vehicles, pedestrians, roadside infrastructure, and cloud networks. The government's commitment to incorporating V2X technology into the development of smart mobility was further emphasised in the "Hong Kong Smart City Blueprint 2.0"[157] published in 2020. The blueprint recognised the significance of V2X technology in addressing the challenges posed by Hong Kong's highly congested transportation system and enhancing overall driving safety.

With unwavering support from the government, the industry has set ambitious goals to achieve tangible and practical use cases by 2025. These include establishing seamless connectivity between key locations such as Hong Kong Science and Technology Park and the Chinese University of Hong Kong, improving transportation links between the airport and Tung Chung city centre, and implementing cross-bay area autonomous driving applications between Shenzhen and the Lok Ma Chau loop area. The government also encourages the use of Kowloon East and West Kowloon as demonstration grounds for exploring Smart City development.

The table below summarises the development guidelines issued by the Hong Kong government to foster and coordinate industry advancements on the topic of smart mobility and CAV.

Hong Kong Smart Mobility Development Guidelines At a Glance

Smart Mobility Roadmap for Hong Kong

Issuing Body : Transport Department

Objectives : Set out a holistic and coherent strategy for implementing a myriad of smart mobility initiatives

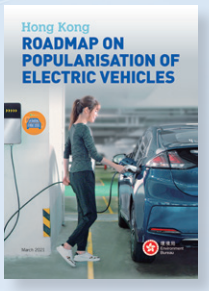
Focus Areas :
- Smart transport infrastructure
- Data sharing analytics
- Applications and services

Hong Kong Roadmap on Popularisation of Electric Vehicles[158]

Issuing Body : Environment Bureau

Objectives : Set out the long-term policy objectives and plans to promote the adoption of EVs and their associated supporting facilities in Hong Kong

Focus Areas :
- Development challenges
- Targets and promotion
- Supporting measures and facilities



2019 2020 2021

Hong Kong Smart City Blueprint 2.0 on Smart Mobility

Issuing Body : Innovation and Technology Bureau

Objectives : Put forth government initiatives in enhancing and expanding residents' benefits from smart city. and innovation and technology (I&T)

Focus Areas :
- Intelligent Transport System and Traffic Management
- Public Transport Interchanges (PTIS)/Bus stops and parking
- Environmental friendliness in transport
- Smart airport

Road Traffic (Amendment) (Autonomous Vehicles) Ordinance 2023[159]

Issuing Body : Legislative Council

Objectives : Amend the Road Traffic Ordinance to provide for a flexible regulatory regime for the pilot use of AV

Focus Areas :
- Regulatory framework to enable trial and use of AV
- Power to disapply legislative provisions

Road Traffic (Autonomous Vehicles) Regulation

Issuing Body : Legislative Council

Objectives : Set out a specific statutory and regulatory regime to facilitate the wider trial and use of AV in Hong Kong

Focus Areas :
- Corresponding penalties for different offences
- Application/ issue/ renewal/ suspension and cancellation of pilot license and AV certificate
- Requirements for insurance coverage and maintenance of pilot AV, journey data, operation records and reportable events

2023

Traffic and Transport Strategy Study[160]

Issuing Body : Transport Department

Objectives : Map out a forward-looking and long-term transport strategy blueprint for Hong Kong with a view to building a reliable, safe, smart, environmentally friendly and highly efficient transport system

Focus Areas :
- Optimise the use of limited road space
- Provide people-centric and efficient public transport services
- Advocate green and active transport as healthy lifestyles
- Embrace opportunities to enhance transport connectivity with other cities in the GBA

CAV Development Progress

On top of government driven efforts, several technology incubators, government departments and quasi-government departments such as the Hong Kong Applied Science and Technology Research Institute (ASTRI), Automotive Platforms and Application Systems (APAS) R&D Centre, Hong Kong Productivity Council (HKPC), Hong Kong Science and Technology Parks Corporation (HKSTP) and Hong Kong Cyberport Management Company (Cyberport) have all played a key role in facilitating collaboration among industry, academia, and R&D for the deployment of C-V2X technology and infrastructure.

Hong Kong Applied Science and Technology Research Institute (ASTRI)

Since 2015, ASTRI has started to develop C-V2X technology and has conducted the first road test at the Hong Kong Science Park in June 2017. In the same year, the Smart Mobility Consortium on Cellular Vehicle-to-Everything (C-V2X) has been formed. Between 2020 to 2022, ASTRI collaborated with Hong Kong Telecommunications Limited and Huawei Technologies Co. Ltd to develop essential roadside technologies for smart mobility. These technologies have been successfully deployed in Hong Kong as well as multiple cities in Mainland China. In 2021, they achieved a major milestone by completing the world's largest C-V2X public road test, covering a 14-kilometer route between the Hong Kong Science Park and Sha Tin Town Centre[161]. In 2023, important steps have been taken with the establishment of the "Smart Mobility Technology (C-V2X) Alliance" (SMTA) to connect stakeholders and enhance co-operation among the Government, industry, academia and research sectors. In the same year, ASTRI has also launched its joint PhD Programme with local universities to nurture I&T talents and enhance the ecosystem.

Looking ahead, ASTRI will be undertaking more projects to deploy C-V2X technologies in various areas, including landfills and passenger buses in East and West Kowloon as well as between Science Park and the University station. These projects are scheduled to be commenced within the next two years, demonstrating ASTRI's dedication to driving the development of CAV technology and smart mobility in Hong Kong.

Automotive Platforms and Application Systems (APAS) R&D Centre

Since the establishment in 2005, APAS has been actively transforming R&D achievements into commercial products through collaborations with industry, universities and institutions. In recent years, APAS has carried out several noteworthy R&D projects, including the development of an autonomous electric tractor for the Hong Kong International Airport (HKIA)[162] and the advancement

of roadside LiDAR and V2X technologies[163]. These technologies are crucial for the expansion and commercialisation of AV.

Numerous real cases of AV adaption have been achieved in the past years, including the 100% self-driving "NAVYA ARMA" AV in the West Kowloon Cultural District (WKCD), and Hercules, the first ever L4 AV project in Hong Kong which has achieved tremendous success in supporting supplement delivery including fresh fruit, vegetables and other supplies to severely affected areas of Shandong and Shenzhen during Covid-19. With the advancement of CAV technology, practitioners are aiming to adopt the technologies in industry-used vehicles, such as refuse collection vehicles and construction trucks.

Hong Kong Productivity Council (HKPC)

Established in 1967, the HKPC is a multi-disciplinary organisation strives at promoting productivity excellence in Hong Kong enterprises. It actively supports the smart mobility initiatives in Hong Kong by collaborating with local industries, enterprises, and world-class R&D institutes to develop applied technology solutions. In 2017, HKPC brought together 20 enterprises from the automotive, mobile networks, transportation and infrastructure industries to form the "Hong Kong Connected Vehicle Cluster", fostering the development in connected vehicles in Hong Kong[164]. In 2019, it became the secretariat and implementation partner of the Smart Traffic Fund, established to enhance commuting convenience, road network efficiency, and driving safety through research and technology applications[165]. HKPC's active support in smart mobility initiatives in Hong Kong creates a strong foundation for continuous development of connected vehicles.

Hong Kong Science and Technology Parks Corporation (HKSTP)

Established in 2001, HKSTP is a technology and innovation incubator that connects stakeholders, facilitates knowledge transfer, and nurtures talents to accelerate technological innovation and commercialisation. HKSTP has formed partnerships with tech ventures and leading corporations in key industries to establish infrastructure and platforms for comprehensive testing and development of CAV applications. In 2022, HKSTP opened a full test site for Urban. Systems to conduct AV trials[166]. In 2023, HKSTP has signed a Memorandum of Understanding with NETA Auto and CATL to accelerate R&D of EV and intelligent driving in Hong Kong. These efforts showcase HKSTP's commitment to attract strategic CAV companies to set presence in Hong Kong, accelerating the smart mobility development in the city.

Hong Kong Cyberport Management Company (Cyberport)

Cyberport is Hong Kong's digital technology flagship and incubator for entrepreneurship. In 2005, it has launched the Incubation Programme providing startups with comprehensive support such as mentorship, marketing, testing, and business matching. The programme encompasses various areas, including smart mobility and other smart living solutions and services. In 2019, Cyberport co-organised the "Technology Forum – Intelligent Transport System and Traffic Management," offering participants hands-on experience with intelligent transportation devices like autonomous self-driving vehicles and unmanned distribution vehicles[167]. Furthermore, in 2023, Cyberport and the Hong Kong SAR Government jointly organised the Digital Economy Summit 2023, with Smart Mobility as one of the key focus areas[168]. These initiatives highlight Cyberport's commitment to fostering innovation in smart mobility.

Other notable smart mobility drivers and collaborations in Hong Kong include:

- **ASTRI and HKT (2018)**

  Established the HKT-ASTRI Smart City Joint Laboratory to pursue advanced solutions for Smart City, with Smart Mobility being one of the initial focuses[169].

- **HKSTP and Urban.System (2022)**

  HKSTP supported the AV trail of Urban.Systems within Science Park[170].

- **ASTRI and Shenzhen Smart City Technology Development Group (2022)**

  Signed a Memorandum of Understanding (MoU) to collaborate on R&D of V2X technologies, with the objective of realising the vision for coordinated development of smart transportation in the GBA by 2035[171].

- **ASTRI and Baidu Apollo (2023)**

  Signed a Memorandum of Understanding (MoU) to promote CAV technology implementation and explore cooperation opportunities in building High-Definition Maps in Hong Kong[172].

- **APAS and CATARC (2023)**

  Signed a strategic cooperation framework agreement to advance the AV and new energy vehicle industries in the GBA[173].

- **HKSTP and Horizon Robotics (2023)**

  Horizon partnered with HKSTP to establish the Technology Innovation R&D Centre at the Science Park, accelerating R&D and deployment of automated driving computing solutions[174].

CAV Development Initiatives

Policy and Regulation

Hong Kong's legislative framework for AV is still in its early stages compared to other Asian locations like Singapore. However, the Hong Kong government has taken steps to amend regulations and introduce incentive schemes to encourage CAV development. The Transport and Logistics Bureau completed the legislative amendments of the "Road Traffic (Amendment) (Autonomous Vehicles) Ordinance 2023" and made a new subsidiary legislation "Road Traffic (AVs) Regulations (Cap. 374AA)" in May 2023 and January 2024 respectively. The new regulatory regime for AVs came into operation on 1 March 2024. On the same day, the Transport Department published the "Code of Practice for Trial and Pilot Use of AVs"[175] to provide comprehensive guidance to the industry in technical, safety and operational aspects to facilitate the trial and pilot use of AVs. In 2024, the Transport Department has plans to take forward various pilot schemes related to the trials of AVs and will announce the "Transport Strategy Blueprint" in 2025 aiming to develop a smart and highly efficient transport system in Hong Kong.

- Amended the regulatory framework of the “Road Traffic Ordinance (RTO)” by introducing the Autonomous Vehicle Licence and Certificate, allowing for trials of passenger-carrying AV. The legislative amendments have laid a foundation for wider trial and flexible uses of AV on Hong Kong roads in the form of a pilot schemes.
- Strict requirements are in place for testing and using AV on Hong Kong roads. Applicants with a pilot license and AV certificate must meet prerequisites including vehicle examinations, registration, insurance coverage, and compliance with AV regulations, ensuring road safety while facilitating AV technology development.
- Launched the “One-for-One Replacement” scheme to promote sustainable mobility. Under this scheme, vehicle owners can register a new EV with a higher First Registration Tax (FRT) concession by scrapping and de-registering their eligible old vehicles[176].

Infrastructure

Hong Kong is actively enhancing its infrastructure to support the development and operation of CAV with traffic data analytics system, real-time traffic detectors, autonomous transportation system, and HKeToll implementation.

- The Office of the Government Chief Information Officer (OGCIO) and TD have jointly launched the Traffic Data Analytics System in 2021. It leverages real-time traffic, transport, and weather data to enhance traffic condition forecasts, establishing a robust digital infrastructure foundation for CAV advancements and improving traffic management efficiency[165].

- As of 2020, over 1,200 traffic detectors and smart lampposts have been installed, providing real-time traffic information to the public via the "HKeMobility" mobile app and the Public Sector Information (PSI) port[157].
- From 2025 onwards, the Airport Authority Hong Kong (AAHK) will implement an autonomous transportation system along the Airport City Link, connecting SKYCITY and the Hong Kong Port Island of the Hong Kong - Zhuhai - Macao Bridge (HZMB). The system is set to expand to include the Tung Chung Town Centre by 2028[177].
- The TD has successfully implemented Hong Kong eToll in 2023. This system allows motorists to conveniently pay tolls using toll tags, eliminating the need to stop and queue at toll booths for payment.

R&D Capabilities

The government has established R&D centres, formed cross-border R&D alliances and provided tax concessions to incentivise R&D institutions in the CAV space.

- ASTRI spearheaded the establishment of the Smart Mobility Technology Alliance (SMTA) in April 2023. The primary objective of SMTA is to create a platform for stakeholders to foster strong connections, enhance collaboration among industry players, research institutions, and academia, and encourage government participation. Through this collaborative effort, SMTA aims to collectively explore solutions and drive advancements in the field of smart mobility.
- The government plans to introduce a bill in 2024 to lower the tax rate for eligible profits generated from patents, from the current 16.5% to 5%. This initiative aims to incentivise increased R&D activities, as well as facilitate the transformation and commercialisation of patented inventions[178].

Supply of Talent

Hong Kong is taking measures to supply talents for CAV development, including establishing the Hong Kong Talent Engage (HKTE) Office, hosting the Global Talent Summit, and expanding student internships under the STEM Internship Scheme.

- In 2023, a physical office of Hong Kong Talent Engage (HKTE) is established to support incoming talents and address their development needs. Additionally, a "Global Talent Summit cum Guangdong-Hong Kong-Macao Greater Bay Area High-quality Talent Development Conference" will be hosted in 2024 to foster regional exchange and collaboration in talent attraction.

- The government is planning to increase the number of student interns from 3,000 in 2022 to 5,000 in 2027 under the STEM Internship Scheme[177], to cultivate young STEM talents.

Access to Funding

Hong Kong provides funding support for research and projects that enhance commuting convenience, road network efficiency, and driving safety, while also facilitates the transformation of R&D outcomes to promote technology transfer and expand marketing services.

- The establishment of the "Smart Traffic Fund" aims to support local organisations in research and applications that enhance commuting convenience, improve road network efficiency, and enhance driving safety. Since 2019, the Management Committee on Smart Traffic Fund has approved 24 projects, with a total grant of approximately USD 17 million[179].
- Introduced the Innovation and Technology Support Programme (Platform & Seed) to provide comprehensive funding support for exploratory research conducted by local universities and applied research with potential for commercialisation. R&D centres can receive up to USD 359 thousand annually to accelerate development[180].
- The Research, Academic and Industry Sectors One-plus Scheme (RAISE+)[181] promotes the commercialisation of R&D outcomes from universities. Institutions can receive up to USD 2.1 million in funding to facilitate technology transfer and expand marketing services.

Hong Kong CAV Development Analysis

Policy and Regulation

- Establishment of the Road Traffic (Autonomous Vehicle) Regulation could facilitate the wider trial and use of AV in Hong Kong in a safe and orderly manner
- Increase transparency on policy updates to allow better public understanding on the latest CAV and EV policies

Infrastructure

- V2X Information Transmission Network enables traffic diversion and facilitates efficient travel route planning for members of the public
- Robust telecommunications infrastructure, characterised by a stable and extensive 4G/5G network, acts as a significant driving force for the development of CAV
- Further expansion of the EV charging station network is necessary to facilitate the development of CAV

R&D Capabilities

- Top-notch universities and training institutes offer programmes in various engineering and technology disciplines
- Free flow of information supports knowledge sharing across countries and innovation development
- Effective IP protection provide competitivity for automakers and technology developers which often involves significant investment
- Positioning as an advanced manufacturing centre in the GBA effectively enhances prototyping and manufacturing of key vehicle components (e.g. sensors)
- International, bilingual nature of Hong Kong customers with good driving behaviour allows for more global features to be integrated into new offerings and enhances the pace of commercialisation
- Support from the GBA research community can facilitate testing and technology transfer in Hong Kong to enhance its R&D efforts
- Proactive efforts are needed to attract automotive companies to establish a presence in Hong Kong and strengthen its automotive industry
- Establishment of advanced automotive testing facilities that provide diverse driving scenarios is necessary to enhance the performance of autonomous vehicles
- Developing large-scale manufacturing centres can help reduce production costs and streamline the prototype design and production process
- Tailored CAV research and development efforts are needed to ensure applicability to Hong Kong's specific conditions (Left vs Right hand driving)

Positive Factors Areas of Improvement

Supply of Talent

- Highly ranked universities in Hong Kong produce skilled graduates in disciplines relevant to CAV technology
- Geographical proximity to other cities in the GBA and talent policies encourage the sharing of talent pool to foster a cross-border exchange of knowledge and expertise
- Cultivation of professionals with multidisciplinary knowledge in robotics and automotive engineering is crucial to building a robust talent pool

Access to Funding

- Comprehensive I&T funding schemes provided by ITC facilitates the adoption of technology by local enterprises/organisations
- Increased efforts should be made to reduce transition cost, secure government support, and encourage investments in CAV by public transportation operators and investors

SECTION 4

Recommendations

STRATEGIC ASPIRATION

In support of Hong Kong's smart city agenda, the development of AV is a key transport strategy outlined in the Traffic and Transport Strategy Study (TTSS) conducted by TD since 2021. Under Hong Kong's high-density built environment, the city can benefit from collaborating with the GBA to develop a world-class CAV system to achieve reliability, efficiency, and environmental friendliness, addressing some of its most pressing challenges in our current transportation system, and hence propelling the advancement of its smart city vision.

A robust CAV system has potential to address diverse needs worldwide. Firstly, CAV technology can reduce the risk of accidents caused by human errors and driver fatigue, thereby enhancing road safety. Secondly, integrating CAV modes with public transportation will alleviate traffic congestion and provide a convenient travel experience. Lastly, promoting energy-efficient practices through the use of smart EV and energy-efficient practices will contribute to Hong Kong's climate goal by reducing carbon emissions and air pollution on the road.

APPLICATION AREAS

Public Sector

Public Transportation

Hong Kong has significant potential for the deployment of CAV technology across various industry sectors. In the public sector, with a heavy reliance on public transportation including the MTR and public bus service which serve as the backbone of the local transportation system, CAV transportations such as autonomous shuttles and minibuses can be deployed. These options can enhance last-mile connectivity in the city's dense urban environment, addressing bottlenecks experienced by local commuters, especially during peak hours, further enhancing the efficiency of our transportation network for the public.

Elderly & Disabled Care

With the increasing aging population, gerontechnology has gained importance in providing services such as transportation assistance, mobile healthcare services, and delivery of medications and daily supplies. By leveraging CAV in these areas, independent mobility can be enhanced, access to healthcare services can be improved, and essential services can be made more accessible.

Private Sector

Tourism & Hospitality

In the private sector, CAV deployment in the tourism and hospitality sector offers numerous benefits. One of the key benefits is the streamlining of airport passenger transfers, providing efficient and reliable transportation between terminals with real-time updates. Within tourist destinations, on-demand CAV can enable convenient sightseeing without navigating public transportation. CAV can also enhance cleanliness, facilitate contactless room service, and improve property safety in hotels and public spaces.

Logistics & Supply Chain

As a major global logistics hub with busy ports serving the South China region, there are also opportunities to utilise AV solutions for optimising routes and speeding up delivery timelines. By harnessing real-time data to adapt routes and avoid traffic congestion, businesses can enhance delivery efficiency and minimise the likelihood of delayed shipments. Furthermore, by offering up-to-date information on delivery schedules and locations, AV can assist in more effective inventory management and planning. In addition, with the growth of online shopping, AV can be deployed for last-mile delivery, efficiently transporting goods from warehouses or distribution centres to customers' doorsteps, reducing delivery times and costs.

STRATEGIC INITIATIVES

The key to successful ecosystem development depends not only on the setting of clear goals and target deployment areas, but also on an orchestrated effort supported by all ecosystem stakeholders. The following section examines the local CAV ecosystem across five key ecosystem enablers, covering policy and regulation, R&D and testing, infrastructure, supply of talent, and funding and commercialisation. Each dimension plays a significant role in informing viable solutions to fostering long-term growth of our Hong Kong's future CAV ecosystem.

Hong Kong Opportunity Summary

	Challenges	Opportunities
Policy and Regulation	• Interdisciplinary expertise among governance institutions needs to be strengthened • Increased transparency in policy updates is required • Enhanced coordination in CAV planning is necessary • Introduction of incentives to promote private market participation is needed	**Cascade strategic directions into effective governance with clear operation guidelines and encourage industry collaboration:** 1.1 Establish a dedicated authoritative committee 1.2 Tighten public and private collaboration
Infrastructure	• Data sharing mechanism needs to be strengthened • Road network requires updates and repairs • Geographical/road characteristics present challenges to development • More EV charging stations need to be installed	**Enable infrastructure connectivity through physical and digital infrastructure uplifts:** 2.1 Foster 4D map development 2.2 Repair and rebuild roads 2.3 Modernise traffic control & operation infrastructure 2.4 Expand EV charging network 2.5 Embed CAV development in urban planning
R&D and Testing	• Knowledge and collaboration in research translation need further integration • Prototype design and production costs are relatively high • Challenges in convertibility of testing data from mainland China • More advanced test roads for autonomous driving need to be developed	**Strengthen translational research capabilities and testing foundations:** 3.1 Establish a centralised knowledge transfer office 3.2 Accelerate testing activities
Supply of Talent	• Supply of multidisciplinary talents needs to be further increased • More efforts are needed to attract leading automotive companies and manufacturers to participate • Greater emphasis should be placed on the application of practical knowledge • Greater readiness in the industry is needed for the adoption of new technologies	**Attract overseas enterprises and create opportunities for knowledge transfer to cultivate local talents:** 4.1 Attract strategic enterprises 4.2 Infuse CAV components in education curriculum 4.3 Reskill and upskill current talents
Funding and Commercialisation	• Public funding for CAV needs to be further increased • Confidence of investors and the market in CAV needs to be strengthened	**Broaden funding scope and sources and promote commercialisation opportunities:** 5.1 Introduce niche CAV-sector funding schemes 5.2 Host cross-border pitching competitions 5.3 Unlock potential for commercialisation activities

Policy and Regulation

In nurturing our CAV ecosystem, one of the most prominent opportunity lies in effective cascade of strategic directions into conducive policy and government support, augmenting the current effort of the government in creating clear guidelines and favourable conditions to cement the city's foundational resources whilst driving industry participation across key ecosystem dimension, bolstering market confidence in this emerging industry for sustainable growth.

1.1 Establish A Dedicated Authoritative Committee

The Hong Kong government took initial steps towards developing CAV by establishing the "Technical Advisory Committee on the Application of Autonomous Vehicle Technologies in Hong Kong" in 2019. The committee comprises representatives and experts from the trade and relevant research and development institutes such as ASTRI and Cyberport. However, the committee's current role is primarily focused on identifying and addressing urgent priorities, such as discussing the regulatory framework for AV trials and identifying suitable testing locations.

To expedite Hong Kong's growth in the field of CAV, it is recommended that Hong Kong establish a dedicated authoritative committee, similar to the UK's CCAV and Singapore's CARTS. This committee, jointly organised by key government departments responsible for transport, roads, and applied research institutes, would consist of academic, research, and industry representatives, and would focus on long-term policy planning beyond sandbox regulatory design. Taking inspiration from Singapore's CARTS, the committee should envision the future of Hong Kong as an AV-enabled city, and accordingly propose AV-enabled mobility concepts for specific areas, accompanied by an implementation roadmap. To ensure transparency and public involvement, the development plan should incorporate regular public hearings and surveys, allowing for public input during the policymaking process. Furthermore, drawing from the UK's CCAV model, it is essential for the committee in Hong Kong to foster close collaboration with relevant government departments such as ITC and HKSTP, to effectively allocate government-backed funds for the development of the CAV sector. By adopting these approaches, Hong Kong can capitalise on the successes of other nations and establish a robust framework for the long-term development of CAV.

Stakeholder involvement is crucial for the overarching strategic design as only by carefully evaluating the gaps between strategy and execution capabilities, could the government truly design a feasible roadmap to meet the unique needs of Hong Kong. It would also be beneficial for Hong Kong to align relevant requirements with China's national standards (Guobiao standards) when possible to drive synergies in supporting cross-border collaboration and enhance cost efficiency in R&D, production and commercialisation process.

1.2 Tighten Public and Private Collaboration

The private sector's involvement in CAV testing in Hong Kong faces barriers, including the reluctance of minibus and taxi license holders to participate due to the perceived high initial cost and risks associated with technology safety and pace of commercialisation. Lack of sufficient information and overseas market failures have also prevented industry players from CAV adoption.

To address this, the government could offer incentives, such as introducing special ownership licenses for license holders, enabling them to support AV development and testing. Public-private partnerships (PPP) could also be utilised, establishing collaborative entities

where private companies can engage in joint technology development, infrastructure building, and operation and maintenance projects under a risk-sharing model. These measures would encourage private sector participation in CAV initiatives. With the increased opportunities to ride on CAV, citizens can experience the convenience brought about first-hand, bolstering their confidence and support for the development of the industry, ultimately leading to widespread CAV adoption.

When developing the risk-sharing mechanism, it is crucial to clearly define the responsibilities and liabilities of the stakeholders involved in the PPP, including the government, private companies and license holders as it helps to address concerns associated with the perceived high risks of the CAV operation model.

Infrastructure

Infrastructure is a key enabler of CAV development due to its vitality in facilitating CAV operating mechanisms as well as safe CAV deployment. In ensuring seamless connectivity, an opportunity lies in the development of CAV-friendly physical infrastructure combined with advancement in key digital infrastructure that Hong Kong has yet to establish to best enable comprehensive deployment of CAV.

2.1 Foster 4D Map Development

Mapping definition software measures road dimensions to the millimetre, highlighting the importance of assimilating all relevant data points. As Hong Kong roads are narrow and tightly surrounded by nuisance items, the need for accurate mapping is paramount. Currently, the 3D spatial data model of the Hong Kong Lands Department has limited coverage of roads, and traffic data is dispersed across multiple government departments. This presents opportunity to future improve data integration and collaboration.

To address this, the Government can promote public private partnerships between mapping companies that possess advanced technologies and knowledge alongside the relevant government departments, such as the Hong Kong Transport and Highways Department, that oversee Hong Kong's transport ecosystem to strategically co-create 4D high-definition maps of Hong Kong roads for CAV. 4D maps are a significant upgrade on 3D maps, as they incorporate the time dimension, and this enables an analysis of changes of road structures or traffic environments over time. This initiative not only reduces the time cost required for the private mapping stakeholders to collect and analyse the road infrastructure points, but also enables the public stakeholders to allocate their funding elsewhere as the mapping development and technological work is executed by the private stakeholder. Such a partnership would ensure the high-definition maps are always accurate and reflective of the infrastructure, as any road degradation or deterioration will be reflected in the data that the public parties will pass on to the private parties to immediately incorporate into the mapping. Such a robust partnership ensures the high-definition maps implemented into AV systems are accurate and detailed, ensuring AV will be safely deployed on Hong Kong public roads.

However, the relevant government departments need to be properly incentivised to participate as well as provide enough funding so potential mapping companies don't refuse to collaborate due to high costs.

2.2 Repair and Rebuild Roads

Hong Kong roads are heavily used, with over 800,000 vehicles travelling on 2238km of roads, signalling an accumulation of significant wear and tear over the years. Hong Kong roads are usually only resurfaced every 20-30 years and remedially repaired on a needs-basis following road inspections managed by the Highways department[182]. In addition, a road quality index

(RQI)[183] suggests that Hong Kong roads still lag behind fellow CAV-leading regions like Singapore and Netherlands.

To remedy this, the Hong Kong Government can introduce a long-standing infrastructure funding initiative that aims to repair and rebuild Hong Kong public roads to make them optimal for CAV. This infrastructure initiative should cover key areas like removing potholes on the road for smooth driving, consistently road striping to renew fading road markers, and repairing or resurfacing damaged roads as a result of decay or the recent typhoons and rainstorm floods in Hong Kong. Hong Kong's roads having well-marked lanes provides easy readability and lane changing functionalities to AV, with on-board sensors being able to easily analyse the road situation accurately. In addition, clear road markers reduce confusion amongst systems and prevent potentially fatal accidents as the AV might mistakenly take the wrong turn or not stop at a roundabout if road markers are hard to recognise. All in all, a systematic repair and rebuild of Hong Kong roads would drastically increase road safety for AV and enable its potential in revolutionising smart mobility to be maximised in Hong Kong.

With that said, undergoing such a large-scale rebuilding initiative could bring about increased disruption, congestion, and inconvenience to drivers and transport users with potential road closures, so the government should roll this initiative out progressively.

2.3 Modernise Traffic Infrastructure

While Hong Kong boasts a robust road infrastructure, there is still a deficiency in the sensors, cameras, and smart traffic tools necessary for CAV implementation. The complex, narrow roads with blind spots further exacerbate the challenge. Upgrading the existing infrastructure, including retrofitting RSU and installing additional sensors, is necessary to support CAV but presents a significant hurdle.

To amend this, the Hong Kong government needs to heavily invest into the required roadside infrastructure that enables connectivity and communication between vehicles and infrastructure. The key 'street furniture' infrastructure elements required to be integrated into Hong Kong roads include smart lampposts and traffic light posts, LIDAR sensors, and various RSU that serve to optimally gather traffic environment data and communicate it to the AV. The installation of RSU and smart road infrastructure near roundabouts, or complex roads that have blind spots should be prioritised as the lower predictability of events transpiring on these roads results in heightened safety concerns and greater need for sufficient RSU. This initiative would aim to enhance the connectivity and connectivity between vehicles and infrastructure, which subsequently improves CAV's operating mechanism and safety functionality. As CAV become safer, this also strengthens consumer confidence towards CAV, which is critical towards the successful deployment of CAV in Hong Kong.

Nonetheless, these cameras would conduct facial recognition without consent, and the government must carefully navigate gaining consumer acceptance and consent on this. A potential alternative to minimise concern about data protection and privacy, would be to implement other non-camera sensors or short distance communication vehicles to facilitate V2X communications.

2.4 Expand EV Charging Network

Industry experts believe that despite Hong Kong's status as one of the most EV-dense regions, the existing EV charging network remains insufficient to meet the increasing demand and usage of EVs. Hong Kong's EV charging network currently only contains 7,085 EV chargers for public use, including 3,950 medium chargers and only 1,092 quick chargers as of September 2023[184].

To resolve this, the Hong Kong government should expand beyond their target of installing 7000 charging stations by 2025[185] , with an emphasis on installing more quick chargers to expand Hong Kong's public EV charging infrastructure across the entire Hong Kong, with a particular focus of implementing charging stations in private residential areas. Some potential future development directions to further enhance Hong Kong's EV charging network include mobile EV charge providers and introducing widescale EV-charging stations that resemble petrol stations. By enhancing Hong Kong's EV charging network, it primarily increases the convenience to EV owners, as well as potentially entices existing petrol car users to transition towards EVs. The consumers user experience is also improved, as more condensed EV charging stations and units across Hong Kong reduces their anxiety of being unable to locate charge on longer road trips. This initiative would fortify Hong Kong's ambitions outlined in the Smart City Blueprint 2.0 as well as spearhead Hong Kong's transition towards the new generation of smart and zero emission mobility.

However, over-accelerating the EV charging network infrastructure expansion would simultaneously diminish parking spots available for petrol car drivers and could potentially lower societal welfare and bring inconveniences to these drivers.

2.5 Embed CAV Development in Urban Planning

Hong Kong's CAV development journey started relatively late compared to other leading neighbour regions e.g. China, Singapore, Korea. Hence, existing towns and infrastructure were not designed with CAV in mind, hindering their seamless integration and deployment.

To address this issue, a key recommendation is to embed CAV requirements in the urban planning of new district. This involves incorporating the principles of connected and autonomous driving into the planning and design of new districts, including road design, traffic management systems, and intelligent transportation systems. In the long run, suitable districts could also incorporate retrofitting to ensure the necessary infrastructure upgrades and connectivity are in place for integrating CAV solutions. This could ensure a seamless integration and deployment of CAV in the city, enhancing transportation efficiency, improving road safety, and contributing to the development of a smart and sustainable urban environment in Hong Kong.

To pave way for the successful integration and deployment of CAV in the transportation system city-wide, it is crucial to conduct targeted public awareness campaigns and provide citizens with more opportunities to ride on AV to increase their

exposure to CAV technology, fostering a positive perception and an informed understanding of CAV.

R&D and Testing

In the rapidly evolving CAV landscape, strong R&D capabilities is fundamental to driving breakthroughs in this technology-driven industry. To establish a prominent position in the CAV value chain, Hong Kong has the opportunity to strengthen its upstream research translation capabilities. Particularly, the city should establish a centralised knowledge transfer portal with GBA collaborations translate research outputs into practical applications. While Hong Kong can leverage the existing testing grounds and cost-efficient manufacturing capability within other cities in the GBA to accelerate CAV testing and production, it should also establish its own testing ground in the long run.

3.1 Establish a Centralised Knowledge Transfer Office

Hong Kong universities have robust research capabilities with their knowledge transfer office driving various research translation efforts to translate basic research into practical industry solutions. However, researchers and experts often seem to be working in silo and scattered across different institutions. Such dispersal hinders the knowledge exchange and inhibits the development of comprehensive solutions.

To further expedite the transfer of research outcomes and intellectual property into commercial applications, Hong Kong could consider to leverage the resources from local incubators such as ASTRI's SMTA and APAS to establish a centralised, virtual CAV knowledge transfer portal. In collaboration with local university knowledge transfer divisions and relevant R&D teams, such virtual platform could be positioned to consolidate CAV-related research outputs, providing corporates and investors quick access to innovative technologies and intellectual properties for further development, serving as a platform for accelerating research translation. Additionally, financial returns for research efforts could incentivise further contributions by university researchers. Combining Hong Kong's upstream research results with the abundant R&D research facilities in the GBA, this would give a competitive edge to the existing applied research centres, accelerating their development efforts.

Collaboration with university knowledge transfer offices would require diligent intellectual property management. Clear guidelines should be established to protect and commercialise the intellectual property generated through research activities. It is also important to ensure a fair mechanism for matching solutions with user needs.

3.2. Accelerate Testing Activities

Currently, AV pilot projects scatter over different locations across Hong Kong, such as science parks, university campuses and private residential estates. However, Hong Kong faces a shortage of advanced test grounds that can provide a wide range of driving scenarios for testing, including mixed trial runs with manually-operated conventional vehicles on public roads. It is important for Hong Kong to explore other virtual and physical avenue to accelerate CAV testing. Meanwhile other cities in the GBA have well established testing sites with presence of trusted third-party testing service organisation. For example, the Shenzhen Future Intelligent Network Transportation System Industry Innovation Centre[186] offers three test areas (close, semi-open and open) that provide comprehensive testing and evaluation services for intelligent connected transportation.

Replicate Real-world Road Tests with Virtual Simulations

Virtual simulations for testing use a variety of data sources such as maps, traffic patterns

and weather conditions to create realistic virtual environment. Virtual vehicles with simulated autonomous driving systems are then introduced within these environments. This allows developers to evaluate system performance efficiently and cost-effectively before real-world implementation. To effectively leverage these diverse data sources, on top of ASTRI's existing efforts in driving virtual simulation for initial testing, collaboration among government departments, such as TD and the Highways Department is crucial to facilitate the sharing of data, ensuring the accuracy and comprehensiveness of the virtual simulations.

Recreate Hong Kong Road Conditions at GBA Testing Tracks

Developers can replicate Hong Kong's road conditions by recreating key elements such as road layouts, signage, and traffic patterns in designated sections of the existing testing facilities in the GBA. This would allow access to advanced testing facilities, saving time and resources that would be required to build new ones.

Develop Advanced Testing Tracks in Hong Kong

Hong Kong can designate selected semi-private and semi-open road segments as dedicated testing grounds, providing controlled environments for testing CAVs. These roads are subject to less stringent road traffic regulations, granting more flexibility for conducting testing activities. For instance, the Energizing Kowloon East Office (EKEO) of the Development Bureau actively encourages all parties to use Kowloon East as a test bed for exploring Smart City development including autonomous driving technologies. The Kai Tak Development Area was also identified as a trial site for CAV technology in view of its current traffic condition, topography and smart readiness. Furthermore, Hong Kong can prioritise areas with robust road infrastructure to support open road testing. For example, the Northern Metropolis area, currently undergoing preparatory work for launching smart motorways, presents a favourable option as it offers both suitable road infrastructure and potentially lower traffic volumes, minimising disruptions and inconveniences for road users.

However, close coordination with local authorities such as the Highways Department, Police Force and the Home Affairs Department, is essential to ensure safe and uninterrupted testing activities in designated road segments.

Supply of Talent

As a talent powerhouse in the region, Hong Kong's talent enhancement strategy combines attracting overseas enterprises and talents to nurture and retain local talent. To address the talent supply challenge in supporting CAV development, there is an opportunity for Hong Kong to bring in GBA enterprises and expertise by encouraging R&D expansion. The local education institutes should also consider extending the curriculum to include more CAV components and collaborate with GBA enterprises to foster knowledge exchange. It is also important to ensure reskilling and upskilling programmes are in place to support taskforce skill transition for them to remain competitive and meet the emerging industry demands.

4.1 Attract Strategic Enterprises

Hong Kong's current CAV landscape is lagging behind neighbouring cities in the GBA such as Guangzhou and Shenzhen. These cities have established a strong presence in the CAV industry, with prominent enterprises like WeRide, GAC Group, and BYD headquartered there. Meanwhile, Hong Kong is working towards attracting strategic CAV companies and showcasing local success stories that can inspire talent.

To further advance its efforts, Hong Kong should concentrate on deepening its initiatives by fostering business matching services, connecting enterprises with potential investors, diversifying their funding source beyond government resources. Moreover, they should facilitate the link up of businesses, facilitating partnerships and collaborations to accelerate commercialisation efforts. The prestige and strong reputation of the enterprises can in turn draw talented professionals seeking exciting career prospects to the city. In addition, Hong Kong should promote and celebrate local success stories in the CAV industry. By recognising and highlighting the achievements of local companies and individuals who have made significant contributions, Hong Kong can inspire the next generation of CAV professionals and showcase its own potential in the industry. Awards, media coverage, and industry events can be utilised to amplify the impact of these success stories and raise awareness of Hong Kong's capabilities. The presence of renowned companies in Hong Kong will create employment opportunities and attract both local and international talent, expanding the talent pool and fostering a vibrant ecosystem.

In order to create a favourable environment for CAV companies to thrive, it is important to develop supportive regulatory framework that encourages innovation and provide clear guidelines. This will enable companies to operate and experiment with new technologies in the city.

4.2 Infuse CAV Components in Education Curriculum

Hong Kong's top-ranked universities offer a range of engineering programmes relevant to the CAV industry but lack specialised tracks on smart mobility. The emphasis on theoretical foundation over practical application limits students' preparedness for real-life CAV scenarios and challenges.

Incorporate Work-Integrated Education into Existing STEM Programmes

Universities should incorporate work-integrated education into current engineering and related programmes. This can involve capstone projects, credit-bearing competitions, practical training in advanced research centres, internships, and industry placements. Collaborations with CAV enterprises, including AV startups, OEMs, telecommunications providers, and innovation hubs in Hong Kong, GBA, or overseas, can be established. Notably, Electrical and Mechanical Services Department (EMSD) has established strategic partnerships with the eight publicly-funded universities in Hong Kong. ASTRI is also collaborating with the University of Hong Kong and the University of Science and Technology on the ASTRI WORK-STUDY Programme (PhD) to nurture R&D professionals. Additionally, mentorship programmes with dedicated industry practitioners should be established to support students' career planning and development. Hands-on experiences will align students with industry needs, enhancing their competitiveness and employability in the CAV sector.

Design Specialised CAV Programmes

Universities should develop specialised CAV programmes that combine electric, electronic, and information communication technology with automotive engineering. This interdisciplinary approach will provide students with a comprehensive understanding

of the complex CAV ecosystem. Project-based learning should be a core component of the specialised CAV programmes, allowing students to gain hands-on experience in designing, testing, and optimising CAV systems. These programmes, opened to students from their second year of regular bachelor programme onwards, allow them to apply their foundational knowledge to solve real-world scientific questions and challenges, fostering innovation. By partnering with GBA industry players on real-life projects, students can gain exposure to CAV challenges and acquire industry-relevant skills. Graduates can find careers with OEMs, automotive engineering companies, research institutes, IT-related companies and other embedded industries.

To ensure the curriculum remains relevant and aligned with industry expectations, it is important to establish regular evaluation and feedback mechanisms to assess the effectiveness of the work-integrated education and identify areas for improvement. The success of CAV programme relies on industry support, including mentorship and training. Strong partnerships and collaborative agreements between universities and industry players will provide students with real-life CAV projects and internships, ensuring a pipeline of highly qualified talent for HONG KONG and GBA enterprises in the CAV sector.

4.3 Reskill and Upskill Current Talents

As AV become commercialised and deployed in the city, the roles and responsibilities of commercial vehicle drivers will evolve. They will gradually shift from being in control of longitudinal and lateral controls to primarily serving as backup systems. While Hong Kong is currently in the development and pilot testing stage of CAV, it is crucial to assist commercial vehicle drivers in preparing for this transition. Additionally, there is a lack of knowledge-sharing opportunities for ecosystem stakeholders to exchange best practices and discuss the latest advancements in CAV technologies.

Transition Preparation for Commercial Vehicle Drivers

The TD should collaborate with industry stakeholders to prepare commercial vehicle drivers for the transition to AV. Training should cover emergency protocols, remote monitoring, and effective passenger communication. This can boost drivers' confidence in handling AV.

Regular Knowledge Exchange for Continuous Learning

Regular knowledge-sharing events, such as conferences, seminars, and workshops, should be organised across Hong Kong and the GBA to enhance the skills of current talent. For instance, EMSD has established six collaborative training bases in Hong Kong and Guangzhou for technical training on vehicle systems and maintenance, covering emerging topics like sensor technologies and EVs. These events would gather industry experts, researchers, and academia to share insights, best practices, and advancements in CAV technologies. By fostering continuous learning, drivers can stay updated with industry developments

To ensure the applicability of the training and learning programmes, close collaboration with technology providers and AV manufacturers is important to ensure the training program aligns with the latest advancements and industry best practices. It is also important to design knowledge exchange events as an ongoing learning process, incorporating feedback to ensure relevance and adaptability to the evolving CAV landscape.

Funding and Commercialisation

Hong Kong's mature financial system hosts the city as a leading financial hubs in the world. There are also a ride range of public and private funding sources

available in the market. In fostering CAV development, there is an opportunity for the government to broaden the funding scope and facilitate access of funding from both local and international markets to support innovative solution development. By tapping into our Chinese and overseas network, Hong Kong could identify investment and adoption opportunities and accelerate the commercialisation process.

5.1 Introduce Niche CAV-Sector Funding Schemes

The Hong Kong SAR government provides financial support for the transportation sector through initiatives such as the "Smart Mobility Fund" and the "New Energy Transport Fund." However, to establish Hong Kong as a leader in the CAV market, it is necessary for relevant institutions to increase the number of approved projects and trails annually.

To boost Hong Kong's upward trajectory in the "CAV race", the government could consider introducing more thematic government funds that specifically target CAV-enabling sectors. Some trending key sectors that have the potential to revolutionise CAV and smart mobility that urgently require funding deployed into include artificial intelligence, robotics, V2X connectivity and communications, as well as semiconductors and microchips. Similar to the existing "Smart Traffic Fund" and "New Energy Transport Fund", these new proposed thematic funds would assess and award funding to applied research trials and projects that possess the vision and capabilities to transform Hong Kong's CAV industry. This initiative broadens the scope of CAV-related access to funding, which strengthens the CAV ecosystem as more resources are simultaneously utilised in ideation, research and development, and deployment of CAV-enablers. Furthermore, as CAV-enabling technologies and solutions proliferate, it further advances the timeline of Hong Kong realising its vision of commercialising CAV on public roads as well as potentially induces more proprietary findings that elevate the operating mechanism and functionalities of CAV themselves.

The government could consider liaising with academia experts to ensure the sector coverage of their funding schemes is comprehensive and in the areas that are critical to the CAV ecosystem and require ample funding injected into.

5.2 Host Cross-Border Pitching Competitions

As the CAV market is still developing, private investors have limited understanding of the CAV SMEs in the GBA and hence hold a cautious attitude towards the prospects of the industry. Furthermore, SMEs in the CAV industry may face cash flow challenges as the current funding mechanism requires companies to make upfront payments before receiving partial reimbursement from the government.

To increase private funding opportunities, various Hong Kong quasi-government institutions with funding incubators and acceleration schemes such as Cyberport and the Hong Kong Science and Technology Park can inaugurate an annual pitching competition that comprises of renowned private investor players in Hong Kong and the GBA (such as venture capitalist), as well as thriving SMEs in the CAV industry developing proprietary technology and solutions. The SMEs would present a pitch deck primarily showcasing their historical financial figures, projections, innovation and R&D progress, and investment highlights, followed by a Q&A session and ultimately the investors confer to rank and decide which SME's have won their investments. This proposed initiative would not only monumentally improve access to private funding for CAV players as this competition acts as a bridge connecting private investors to lesser-known SME's who could benefit from funding to upscale their operations and selling proposition development, but also provide

greater assurance and clarity to investors on CAV technology as a government-endorsed fundraiser instils confidence. In addition, such a competition also enables increased networking amongst industry peers, fosters knowledge sharing, and diversifies business matching opportunities. All in all, this initiative could further spearhead Hong Kong's CAV industry growth as increased funding unlocks more potential industry-transforming and accelerates the development of the industry.

To maximise the effectiveness of this pitching competition, the Hong Kong government must implement a rigorous screening process to identify the best positioned SME's and devise incentives to attract the prominent private investors to participate.

5.3 Unlock Potential for Commercialisation Activities

Hong Kong, as a key city in the Greater Bay Area, enjoys exceptional connectivity and proximity to major cities in Southern China. This strategic location fosters cross-border partnership and commercialisation activities with the CAV space. Additionally, Hong Kong's intricate road network, high traffic volume, top-notch infrastructure, and robust legal framework make it an ideal demonstration zone for innovative CAV solutions. It provides companies with the opportunity to validate their technologies before expanding to other markets.

To further promote CAV commercialisation, Hong Kong can regularly organise industry events and exhibitions, showcasing CAV products. Moreover, it actively promotes its demonstration platforms, such as those in the Hong Kong International Airport, West Kowloon, East Kowloon and Discovery Bay, to demonstrate technology feasibility and facilitate partnerships for CAV commercialisation. By serving as a conduit for CAV enterprises within the GBA to access the international market, Hong Kong can strengthen its global reputation as a leading innovation hub.

To effectively reach a global audience and attract visitors and exhibitors beyond the local region, collaboration with international industry associations and trade organisations is crucial in positioning Hong Kong as an international platform for CAV commercialisation. This could take place in the form of joint programmes, conferences, and exhibitions to showcase Hong Kong's CAV capabilities and facilitate knowledge sharing. Collaborative market promotion efforts, such as joint marketing campaigns and participation in international trade shows, will further establish Hong Kong as an international platform for CAV commercialisation.

SUCCESS STORIES

HONG KONG APPLIED SCIENCE AND TECHNOLOGY RESEARCH INSTITUTE

FACTS & FIGURES

Kickstarted V2X technology research since 2015

Developed Hong Kong's first autonomous minibus (AiBus) and autonomous shuttle bus that connects the Hong Kong Science Park and the University MTR station

Conducted one of the world's largest C-V2X public road test in Hong Kong in 2021

> Hong Kong can leverage the abundant resources and capabilities of the GBA to propel R&D and commercialisation of C-V2X applications in the city, establishing a robust foundation for the advancement of our smart city initiatives.

Dr. Lawrence Poon
Former Head of Innovative Technology and CEO's Advisor of ASTRI

Leading the Way at Applied Technological Research

Founded in 2000, the Hong Kong Applied Science and Technology Research Institute (ASTRI) is the largest applied research centre in Hong Kong. Its mission is to enhance Hong Kong's competitiveness through applied research. ASTRI has been actively developing technologies for smart city applications since 2015. One of its notable achievements is the development of autonomous trucks to support waste management at landfill sites for addressing labour shortage. In 2023, ASTRI launched the Smart Mobility Technology (C-V2X) Alliance (SMTA) as a platform for networking, knowledge sharing, and exploring collaboration and technology commercialisation opportunities.

Leveraging the GBA to Advance C-V2X Infrastructure & R&D

Intelligent transport infrastructure is the foundation for connected and autonomous vehicles (CAV). In support of this, ASTRI and Baidu Apollo have joint hands in May 2023, combining Baidu Apollo's expertise in C-V2X infrastructure development with ASTRI's technological capabilities across 5G communication, AI, and smart mobility for enhancing Hong Kong's roadside infrastructure. Particularly, the collaboration has planned to build High-Definition (HD) Maps for precise navigation for further enhancing CAV safety.

Furthermore, ASTRI is tapping into the GBA's R&D manpower to accelerate CAV testing. For instance, ASTRI is collaborating with the Shenzhen SmartCity Technology Development Group whereby the two organisations will collaborate on connectivity research, operation standardisation, and testing of C-V2X applications in both Hong Kong and Shenzhen. Through leveraging GBA's expertise in infrastructure and R&D, Hong Kong will be able to accelerate the pace of development, ensuring that it remains at the forefront of building a comprehensive CAV ecosystem.

Unlocking Potential for Funding & Commercialisation

When it comes to commercailising CAV efforts, ASTRI is also working with the mainland China and rest of the GBA to expand funding support. Following the establishment of the "Dedicated Fund for ASTRI Yangtze River Delta Centre for Technology Transfer in Suzhou" in May 2023, this RMB 100 million fund aims to support the commercialisation of new technologies developed by enterprises in ASTRI and Suzhou. Furthermore, ASTRI and the Suzhou Municipal Xiangcheng District People's Government have signed a Strategic Partnership Agreement on Digital Transportation in the same year which aims to fully develop the Suzhou-Hong Kong digital transportation I&T corridors, leveraging the respective strengths of both regions in the smart mobility industry. This partnership is poised to facilitate innovation exchange across the border, expediting the commercialisation of CAV technologies in the GBA.

Looking forward, ASTRI will continue to work with partners from various fields in smart transportation. These partners will include universities, OEMs, driverless vehicle developers, telecommunications service providers and more. This could facilitate major breakthroughs in smart mobility, allowing the integration of CAV technologies into various smart city scenarios such as smart terminals, smart parks and smart highways, ultimately enhancing road safety and improving traffic efficiency in Hong Kong.

AIRPORT AUTHORITY HONG KONG

FACTS & FIGURES

First airport in the world to apply Autonomous Electric Tractor (AET) in live operations and in large scale; 41 AETs have been introduced

Deployed eight Autonomous Patrol Car (APC) to enhance security along the borders of the airport's restricted area

Introduced three Autonomous Shuttle Buses

> Early engagement with key stakeholders including the governmental authorities and regulators as well as business partners is important to ensure transparency and alignment of understanding.

Ms. Lily Lai
Chief Information Officer of Airport Authority Hong Kong

A Growth Engine for Hong Kong's Aviation

The Airport Authority Hong Kong (AAHK) is a statutory body wholly owned by the Hong Kong SAR Government. Established in 1995, AAHK is responsible for the operation and development of Hong Kong International Airport (HKIA), with a view to strengthen HKIA as the leading international aviation hub, and a key engine for the economic growth of Hong Kong. AAHK set out a 10-year technology roadmap back in 2021, and has been implementing programmes under the roadmap. Automation, for instance, is a key component of the roadmap.

HKIA as an International Testbed for Revolutionising Airport Operations

HKIA has been ranked as the "Best Airport in the World" consistently by different organisations for its high volume of passengers and cargoes, and efficiencies. Industry experts have touted HKIA as an ideal environment to provide a diverse range of real-world scenarios to test and refine CAV technology. Since 2019, AAHK has been progressively deploying Autonomous Electric Tractors (AET), Autonomous Patrol Car (APC), and Autonomous Shuttle Bus technology to revolutionise its operations. The AETs are the first-ever tractors incorporated into live airport operations in the world to assist in luggage and cargo delivery in 2019. The APCs are modified EVs that aid daily patrolling at the border of restricted areas 24 hours a day, automatically detect if someone has entered the warning zone by using video analytics. The Autonomous Shuttle Bus has been in operation since mid-2023. The introduction of these services exponentially enhanced airport safety and security, transport and operational efficiency whilst reducing staff workload.

Continuous Development of “Airport City”

HKIA is transforming from a city airport into an “Airport City” by adding new functions and services, including travel, exhibition, entertainment and retail, to the airport. HKIA will become a new landmark in Hong Kong and the region, as well as a key engine for the economic growth of Hong Kong. Meanwhile, as a gateway connecting the Greater Bay Area (GBA) and the rest of the world, AAHK has been enhancing the transportation of HKIA and the GBA, such as developing the Airportcity Link. The Airportcity Link includes an autonomous transportation system connecting SKYCITY and the Hong Kong port of Hong Kong-Zhuhai-Macao Bridge (HZMB), and will further extend to Tung Chung Town Centre, in order to enhance the connectivity between Hong Kong and the GBA, as well as drive the development of business, catering and entertainment.

AAHK has been developing two automated car parks in the restricted area of the Hong Kong port of HZMB, namely "Park & Fly" and "Park & Visit", in order to attract more travellers from the GBA to use HKIA for their international travels or visit Hong Kong.

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACTS & FIGURES

Has 40+ professors specialising in diverse robotics fields, including autonomous driving

Established 10 research centres in Shenzhen and 16 research centres in Guangzhou

> One of Hong Kong's strengths lies in its commitment to provide an exceptional learning environment for students. At HKUST, we encourage students to engage in CAV competitions where they can learn beyond classrooms, acquire hands-on field knowledge from their peers across universities and regions.

Prof. ZHANG Fumin
Chair Professor of Electronic & Computer Engineering and Mechanical & Aerospace Engineering, and Director of the HKUST Cheng Kar-ShunRobotics Institute, Institute of Electrical and Electronics Engineers (IEEE) Fellow

Where Knowledge Meets Discovery

Established in 1991, HKUST is a renowned public research university committed to advancing knowledge through teaching and research. HKUST launched Cheng Kar-Shun Robotics Institute (CKSRI), a major new multidisciplinary research initiative. The Institute supports the endeavours of faculty and students working on robotics and autonomous systems across the campus. The CKSRI is a multidisciplinary platform that supports and facilitates robotics-related research, development and education. With a focus on autonomous systems and robotics research, the Institute integrates innovations in sensors, devices, systems, networks, neurosciences, data analytics and machine learning to further research by faculty and students in a wide range of applications that aim to create societal impact. The Institute also nurtures a network of industry partners, designs entrepreneurship programs and drives knowledge dissemination.

HKUST boasts a wealth of talent in the Automated Driving System field, equipped with extensive industry expertise. Moreover, the university's research centre has branches in Hong Kong and Guangzhou to facilitate talent development in the field of intelligent autonomous driving. The key to commercialisation success lies in its collaboration with the university's Office of Knowledge Transfer where it partnered with ASTRI to facilitate collaboration with midstream and downstream sector players, expediting the technology licensing process. The robust support system provided by HKUST, encompassing cutting-edge research capabilities, as well as a collaborative knowledge transfer centre has allowed researchers to focus on their core expertise while effectively translating their innovations into practical applications benefiting the campus and beyond.

Nurturing Future Innovators through Experiential Learning

Apart from infusing CAV knowledge in robotics courses, the HKUST School of Engineering actively integrates CAV elements into learning through applied theory practicum courses in its undergraduate curriculum. It emphasises the importance of competition in undergraduate learning, encouraging students to participate in faculty-organised and international CAV-related competitions while gaining academic credits. In the recent Virtual RobotX Competition 2023, the HKUST team secured second place with their remarkable autonomous surface vehicle. Additionally, the school offers the Undergraduate Student-initiated Experiential Learning Programme, enabling students to pursue CAV research and design projects that aligned with their interests. This unique approach cultivates entrepreneurship on campus, enhances students' practical skills and prepares them for the dynamic world of CAV innovation after graduation.

Looking ahead, HKUST aims to enhance research in robotics and automation technologies by expanding collaborations beyond local players such as the MTR Corporation and strengthen relationships with enterprises in the GBA through joint research centre initiative such as the HKUST-DJI joint innovation laboratory to accelerate automation technology advancements.

A GLOBAL LEADING TECHNOLOGY PLAYER

FACTS & FIGURES

A global network 17,000+ technology startups under the company's startup incubation programme

Features 100+ Hong Kong startups within the programme which focus on computer vision for smart mobility, robotics, and language modelling

> Thanks to advancement in GPU and other digital twin technologies, AV testing can now be done through virtual simulation that allows driving in Hong Kong's virtual replica with high-fidelity visualisation of driving scenarios, significantly reducing the risk and cost before physical testing.

Senior management executive at the company

One of the Best Industry Labs for AI Research

The renowned technology company established an international research lab in artificial intelligence. Riding on Hong Kong's thriving I&T environment, the research lab focuses on engaging universities and research institutes in AI research across Smart City, Financial Technologies, Intelligent Manufacturing, and Health Technologies.

Addressing Hong Kong's Testing Ground Shortage through Virtual Testing

Diverse testing environments are crucial for refining technology and ensuring safety for autonomous vehicle (AV) technology. However, Hong Kong lacks such testing grounds. To address this, the company has created a virtual proving ground for AV development. This cloud-based platform generates real-world driving scenarios, empowering developers to train and evaluate self-driving systems thoroughly. Capitalising on Hong Kong's comprehensive I&T environment, as well as its solid hardware and software support, this virtual testing platform can overcome limitations of physical testing, enhancing safety and reliability under a cost-efficient manner. AV developers in Hong Kong can conduct comprehensive testing via road traffic and weather condition simulations, minimising the reliance on physical testing while achieving comprehensive results.

Driving Talent and Funding Development through Virtual Incubation

In addition to research testing, the company has also established a virtual incubation programme that offers R&D assistance and investor matching for startups. This programme leverages the company's research know-how through providing free trainings, discounted workshops and exclusive networking events, enabling startups to enhance their knowledge and showcase their innovations to corporates around the world. From this programme, startups also have the opportunity to connect with venture capitalists and corporate investors, securing additional funding beyond government sources. By facilitating these connections, the programme opens up new avenues for startups to secure necessary R&D and financial support for accelerating commercialisation of R&D outcomes.

Looking ahead, the company sees a great opportunity in advancing testing capabilities in Hong Kong through AI applications. Supported by the city's ease of funding access, Hong Kong is poised to create a thriving ecosystem for CAV commercialisation.

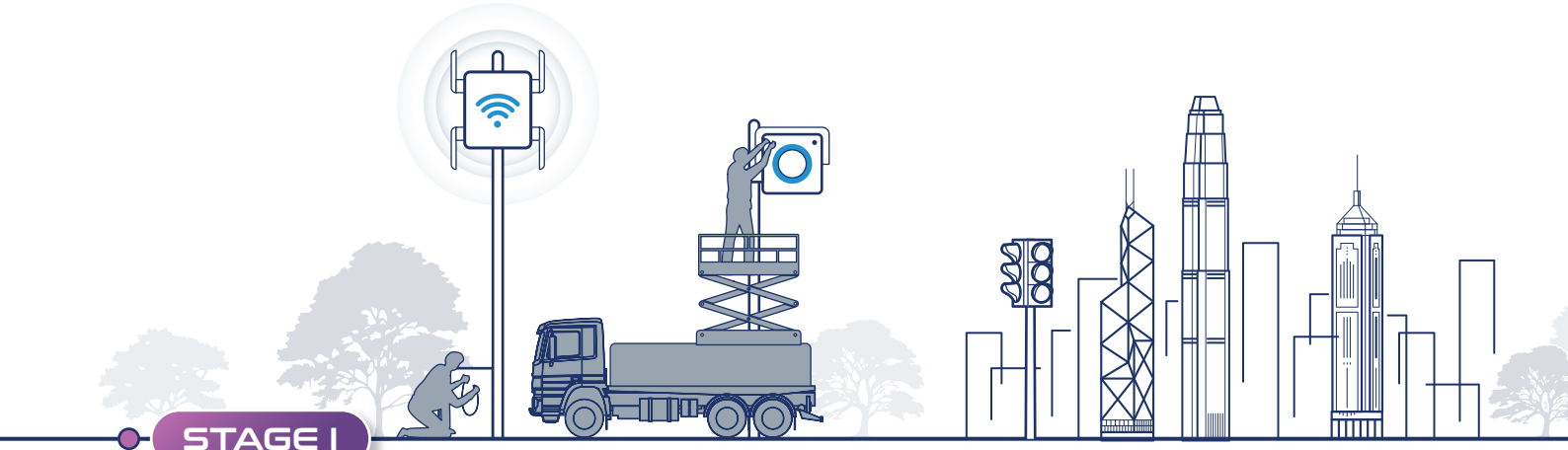
SECTION 5

Path Forward

HIGH-LEVEL DEVELOPMENT ROADMAP

Looking forward, Hong Kong should consider staging the CAV development roadmap carefully, ensuring clear goal setting from top down and cascade the strategic directions to reinforce the key operational activities required for the years to come.

	STAGE I	STAGE II	STAGE III
	Foundation Enhancement (1-3 years)	**Development Coordination** (1-5 years)	**New Industry Incubation** (3-8 years)
Goal	Pilot testing of standard routes within a safe and controlled environment (e.g. campus, private roads, amusement parks, industrial parks)	Testing of standard routes on a town level, involving routes in a hybrid environment that encompasses controlled and real-life environment (e.g. Airport to Tung Chung town)	Full deployment with seamless integration of autonomous and manual vehicles in real-life environment (e.g. Northern Metropolis public roads)
Action	Strengthen existing smart mobility policies and foundation infrastructure to drive sustainable growth	Deepen development efforts by fostering CAV-specific initiatives across industry and ecosystem groups	Create a supportive environment that nurtures the emergence of AV and its associated, new products and services in the market
Strategic Initiatives	1.1 Establish a dedicated authoritative committee 2.1 Foster 4D map development 2.2 Repair and rebuild roads 2.3 Modernise traffic infrastructure 2.4 Expand EV charging network 3.1 Establish a centralised knowledge transfer office 3.2 Accelerate testing activities 4.1 Attract strategic enterprises	1.2 Tighten public and private collaboration 4.2 Infuse CAV components in education curriculum 5.1 Introduce niche CAV-sector funding schemes 5.2 Host cross-border pitching competitions	2.5 Embed CAV development in urban planning 4.3 Reskill and upskill current talents 5.3 Unlock potential for commercialisation activities



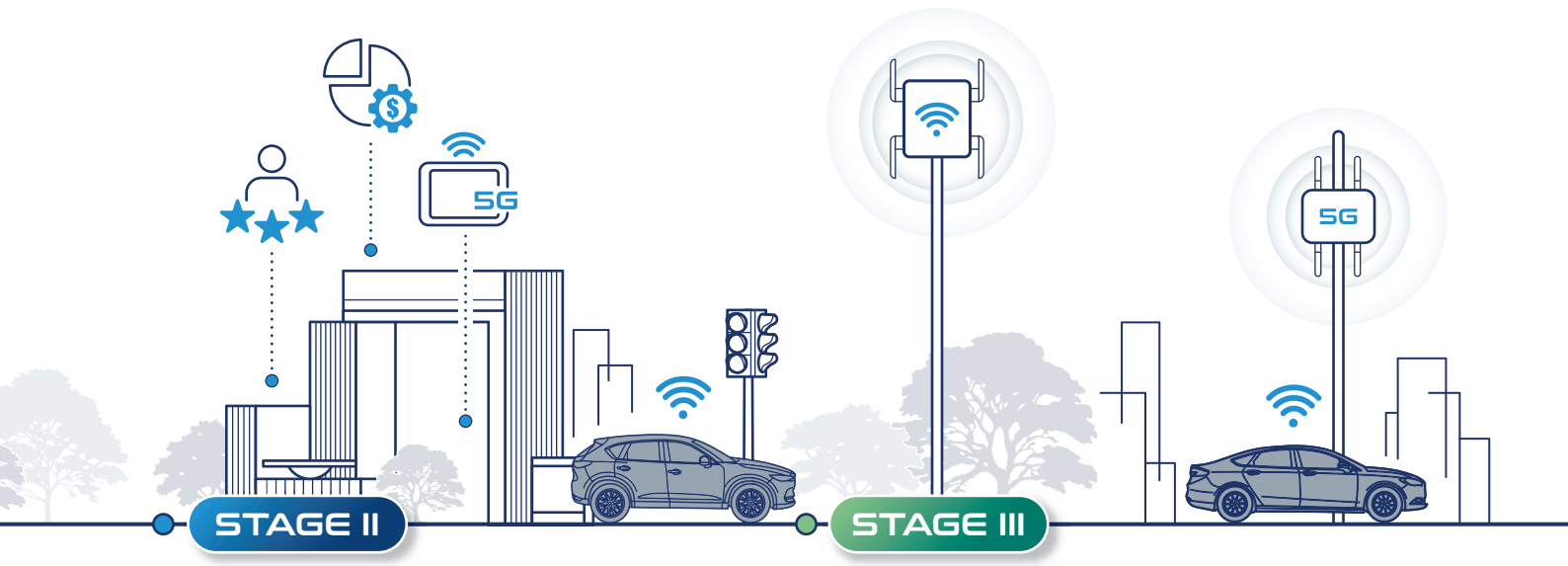
STAGE I

Foundation Enhancement (1-3 years)

Stage I of this development roadmap primarily revolves around building the underlying foundational infrastructure as well as strengthening Hong Kong's existing transport mobility ecosystem and smart mobility policies for CAV industry development and deployment in Hong Kong.

In allowing the formulation of building blocks as well as key enablers within Hong Kong's ecosystem to best facilitate exponential growth and advancement in the CAV space, Hong Kong should see policy and regulation dimension, predominantly developing a clearly defined and robust regulatory policies framework through a centralised governing body with enhancement of guidelines as a pre-requisite for attracting market investment. Then modernising Hong Kong's physical and digital infrastructure, strengthening R&D, talent and funding capabilities through leveraging GBA resources as well as taking advantage of Hong Kong's world-leading university talents and investor network are also the recommended focus areas to best incentivise CAV industry growth.

The end goal upon the successful implementation of the proposed initiatives is for Hong Kong's CAV development to reach the milestone of being able to conduct pilot testing on standard roads within a safe and controlled environment.



Development Coordination (1-5 years)

Stage II focuses on deepening the development efforts within the CAV industry. This is achieved through fostering CAV-specific initiatives that primarily aim to forge collaboration between the public and private sectors in terms of talent and funding. This represents a significant transition from foundational work to practical implementation.

Through encouraging coordinated efforts, key factors such as fostering collaboration, grooming the next generation of talents and supporting test trials with funding and adoption opportunities should be considered. Collectively, these initiatives should pave the way for validated technologies and a strengthened ecosystem, ultimately leading towards future commercialisation. Collaboration among industry players is crucial during this stage to collectively prepare for the widespread transition and adoption of CAV technologies.

Ultimately, the goal of this stage is to be able to conduct testing on standard public routes at a town level, aiming to validate and refine CAV technologies for safe and efficient operation in real-life scenarios in controlled environments such as the Hong Kong International Airport and in selected public road routes similar to the 14km route from Hong Kong Science Park to Sha Tin town centre in ASTRI's previous study.

New Industry Incubation (3-8 years)

The last stage of the development roadmap, known as "New Industry Incubation", aims to leverage the foundational policies, infrastructure and R&D efforts as well as coordinated development across talent and funding to create a supportive business environment for the emergence of innovative AV products and services in the market.

To successfully usher into the final stage of this roadmap, robust urban planning, workforce transition and commercialisation acceleration are critical. The economic benefits of this societal shift cannot be understated, as new smart towns and job positions such as CAV safety controllers and operators and other Mobility as a Service (MaaS) practitioners are created.

Moving forward, various Hong Kong districts should be identified and selected for full CAV deployment trials, with the ultimate goal of seamlessly deploying and integrating AV alongside manual vehicles on all public roads of selected new towns or districts, such as the Northern Metropolis.

CALL-TO-ACTION

In driving sustainable CAV development, each ecosystem group plays a pivotal role alongside government efforts. As the demand for innovative solutions grows, private companies bring valuable expertise, resources, and entrepreneurial spirit to the table.

Upstream - Technology & R&D players

Talent Cultivation:

Develop CAV-relevant curriculum, providing practical training through experiential learning and industry placement opportunities in the GBA, grooming the next generation of CAV talents and industry professionals.

Research Translation & Collaboration:

Foster international partnership and establish centralised knowledge transfer office that connects the academia, researchers, and automakers and service providers to accelerate research translation.

Testing & Validation

Integrate Hong Kong's virtual and closed-course test results with advanced testing data in GBA replicas to overcome hurdles in AV testing.

Policy Advocacy

Collaborate with policymakers and regulators to provide support on shaping safety standards and liability frameworks, mitigating uncertainties to drive market participation.

Midstream - Automakers, Service Providers and Incubators

Infrastructure Preparation

Invest in the development of robust infrastructure, including map development, smart road and infrastructure, and charging network upgrade to drive widespread adoption.

Manufacturing Adaptation

Leverage GBA manufacturing capabilities to accelerate prototyping and efficient production of CAVs, achieving supply chain resilience and cost efficiency.

Service Innovation

Introduce new CAV-related services such as Mobility-as-a-Service (MaaS), autonomous ride-hailing, and in-vehicle infotainment solutions, delivering personalised and seamless experiences to drivers and passengers.

Industry Incubation

Establish inception programmes to provide mentorship, funding and business matching opportunities to bridge innovations with market needs, fostering a vibrant ecosystem for innovation commercialisation.

Downstream - Distributors and Users

Fleet Integration

Embrace CAV technology in fleet operations, leveraging automation and connectivity to optimise efficiency and enhance passenger experience.

Workforce Transition

Transition the workforce through reskilling and upskilling to ensure seamless integration and adaptation to the evolving CAV demands.

Public Education

Raise public awareness and trust in CAV technology through educational campaigns on benefits and safety aspects and celebrate industry successes to build market confidence.

Feedback & Improvement

Drive user engagement and feedback to enhance CAV technologies, meeting evolving needs and expectations of different customer segments.

CONCLUSION

The CAV industry in Hong Kong enjoys a strong infrastructure foundation, a robust academic and research network, accessible financing channels, and comprehensive government support. With the recent revision and implementation of regulations concerning autonomous vehicles by the Hong Kong government, it is imperative for Hong Kong to enhance collaboration with all sectors to advance the vision of deploying CAV on Hong Kong roads.

Whilst Hong Kong continues to enhance its capabilities and resources in the CAV realm, there is enormous potential for the city to expedite the development from collaborating with the GBA where CAV technologies already go beyond piloting in restricted environments and are more mature in terms of trial and use of AV as well as standardising relevant technical requirements and industry practices.

Through cascading coordinated strategic directions from top-down into enhanced governance model with clear operation guidelines and further alignment with the standards of China's CAV industry, enhancing physical and digital infrastructure connectivity, strengthening translation research and testing capabilities, attracting leading overseas enterprises and grooming the next generation of local talents, and accelerating cross-border funding and commercialisation opportunities, the city could capitalise on untapped market opportunities to nurture the end-to-end CAV ecosystem, achieving unprecedented breakthroughs to thrive in the evolving mobility sector.

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Research Partner

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