Department for International Trade

SOUTH KOREAN MARKET INTELLIGENCE REPORT 2019

CONNECTED AND AUTONOMOUS VEHICLES

Department for International Trade

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FOREWORD

South Korea has been one of the world's top automotive manufacturing countries and one of the largest automotive exporters since the 1990's. The auto industry remains one of the key sectors in the South Korean economy, accounting for 13% of output of the manufacturing sector and contributing over 10% to GDP. This has not been achieved by standing still. South Korea spends more on R&D than any other country in the OECD. They have started to adapt to future mobility technology and development, particularly in autonomous vehicles, clean fuel and the zero carbon emission agenda. In January 2019 the South Korean government unveiled its vision for a hydrogen-powered economy and Hyundai Motor Company has also set up new divisions in charge of hydrogen electric vehicles, CAVs and artificial intelligence for smart mobility.

According to the SMMT (Society of Motor Manufacturers and Traders) South Korea ranked sixth as an export destination for UK cars, showing UK exports to Korea up 23.5% in 2018 and what this report makes clear is there are also a growing number of exciting opportunities for innovative UK companies to collaborate with South Korea on the future of the automotive industry.

DIT Seoul is committed to helping UK exporters gain access to these opportunities in South Korea - leading the way together in this fast moving industry. We are pleased to bring this report to you in partnership with Intralink and the SMMT.

Mike Welch
Director of Trade and Investment
DIT Seoul, British Embassy Seoul

WELCOME

The global automotive sector is going through a period of unprecedented change, with new technologies and business models that will change the way we own and use vehicles. The shift to Connected and Autonomous Vehicles (CAVs) will mark the biggest change to how we travel since the invention of the motor car.

However, the scale of the challenge in delivering autonomy is such that no one company or country has all the answers – collaboration is key and we increasingly see cross border partnership between manufacturers, suppliers and technology companies, to develop solutions for the future of mobility.

The UK is one of the world's leading centres for automotive engineering, technology and innovation and has a strong position in the development and testing of CAVs. Autonomous driving trials are taking place in our cities and there are four major CAV test beds. Our light touch approach to regulation and support from government make the UK the ideal location for companies to test and deploy automated vehicles.

As this report demonstrates, the CAV market in Korea is expected to grow rapidly with a market size as high as £2.5 billion by 2025, opening up significant new business opportunities.

The UK's position in CAV combined with the strong UK – Korea relationship in automotive means UK firms are well placed to access these opportunities.

The Society of Motor Manufacturers and Traders welcomes this report and is pleased to be working with the Department of International Trade and Intralink to help UK companies access opportunities in Korea.

Mike Hawes
Chief Executive
The Society of Motor Manufacturers and Traders

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INTRODUCTION

South Korea (Korea) offers significant opportunities for British connected and autonomous vehicle (CAV) companies with both the public and private sector investing heavily in innovative CAV technologies. Korea's state-of-the-art ICT infrastructure is already world class and full, nationwide 5G coverage is expected to be achieved by 2022. This strength in network technology, along with the country's globally competitive automotive sector, offers a strong foundation for rapid commercialisation of self-driving vehicles and makes Korea a highly attractive market for UK CAV technology and solution providers.

The Korean automotive industry is the 7th largest in the world with the country producing over 4 million vehicles in 2018. Hyundai Motor Company dominates the domestic market with its three OEMs, Hyundai Motors, Kia Motors and Genesis Motor, commanding a 70% market share. The CAV market is developing rapidly with current market size estimates ranging from GBP 70 million to GBP 100 million, but experts predicting that the market will be as large as GBP 2.5 billion by 2025. These optimistic projections are echoed by KPMG's recent analysis that ranks Korea's CAV sector among the world's best in terms of CAV infrastructure and technology and innovation, pointing to the fact that the country is defining global standards in terms of 4G coverage and AV-related patent registration per capita.

The Korean government has designated autonomous vehicles as a focus area for R&D efforts and announced significant investments to support this policy. K-City, Korea's largest connected and autonomous vehicle testing ground spanning 360,000m^2, is perhaps the most notable example of the government's policy. Other large-scale projects related to CAV have been announced in Seoul, Daegu, Pangyo and Sejong City, underlining the government's commitment to the rapid commercialisation of CAVs. Regulatory frameworks to support the industry are also being drafted with several amendments having been adopted from 2018.

Korean automotive and ICT companies alike are actively working to secure their position in the rapidly growing CAV market. Key players from the automotive industry include Hyundai Motor Company, Hyundai Mobis and Mando, who have centred their investment and research activities around sensor technology, including camera's, LiDAR and radars, as well as control hardware and software. Electronics giants Samsung Electronics and LG Electronics are also taking strides in the CAV sector and are directing their attention towards In-Vehicle Infotainment (IVI) and V2X solutions. Telecom companies SK Telecom and Korea Telecom (KT) use their network capabilities to focus on V2X solutions and HD mapping, while local IT players such as Naver Corp and Kakao Corp apply their AI and IT expertise to development programs in IVI and mapping.

This combination of an advanced infrastructure, government support and investment, along with major automotive and technology players' commitment to the field has created fertile ground for British companies with innovative solutions to find strong local partners. Key opportunity areas include autonomous driving technology (e.g. low-cost LiDAR solutions, artificial intelligence software and vehicle control hardware), V2X (both C-V2X and DSRC solutions) and IVI and HD mapping solutions. A growing awareness among the country's CAV community that the UK is a world leader in the field of CAV means British companies with the right go-to-market strategy will find a warm reception among potential Korean customers and partners.

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KOREA – AN OVERVIEW

Key Points

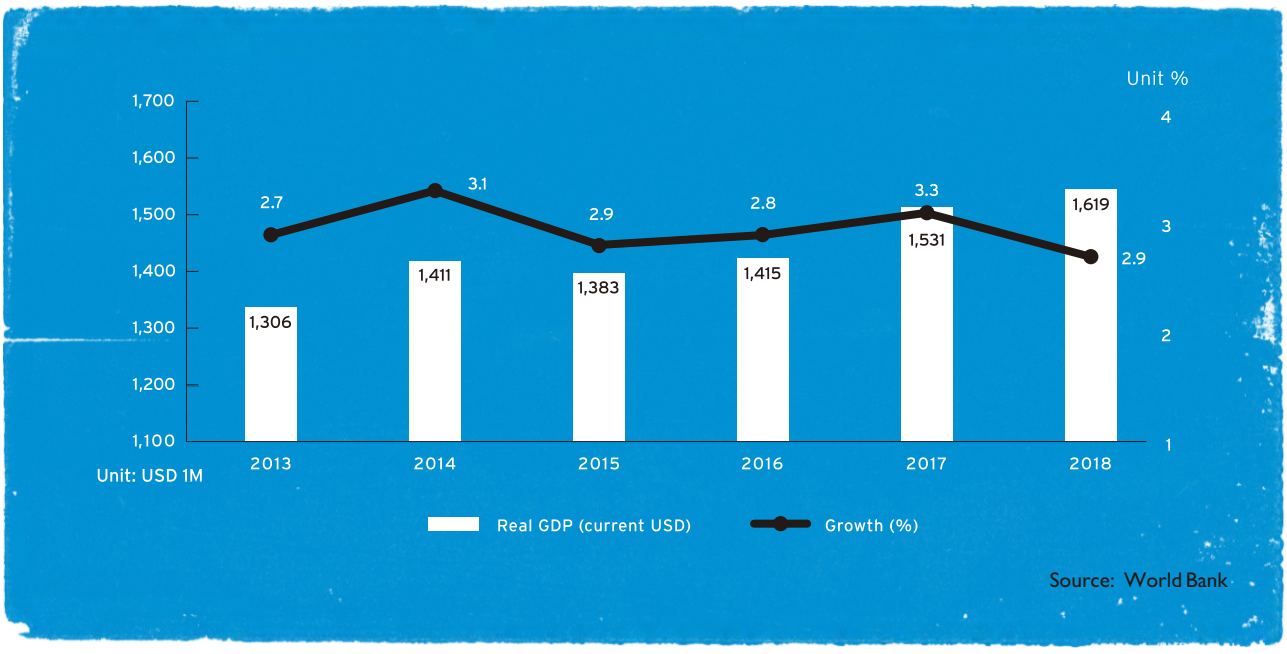
- Korea has climbed out of poverty to become a technology powerhouse over the last 60 years
- The country is the world's 11th largest economy with a GDP of just over GBP 1 trillion
- It has maintained an annual GDP growth rate of around 3% in recent years

In the space of just 60 years, Korea has transitioned from an agricultural economy to one driven by high- value industries such as automotive, shipbuilding and advanced manufacturing. Perhaps most remarkable of all is the country's success in the areas of electronics and information communications. As well as dominating the global semiconductor industry, Korea has leap-frogged its peers in terms of ICT infrastructure (smartphone penetration rate, broadband speed, etc.) and this fact, coupled with a demanding and technology- embracing population, means Korea is becoming an economy driven by creativity and innovation.

With a population of 51 million people, Korea boasts the 11th largest economy in the world, a GDP of nearly GBP 1.3 trillion in 2018 and a per capita GDP of GBP 24,980 in the same year. The country has maintained strong annual growth for a developed economy of close to 3% in recent years, outpacing its regional rival, Japan.

Korea's trade dependency ratio is extremely high at over 80% and its economic performance is heavily affected by the economies of China, the US and Japan. Trade and investment flows between Korea and the EU are growing as a result of the FTA that came into effect in 2011. Trade between Korea and the UK specifically has grown rapidly over that period and both countries have expressed a strong desire to conclude a trade deal once the UK leaves the EU.

Figure 1: Korean GDP (2013 – 2018)



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THE CAV INDUSTRY IN KOREA

Key Points

- Korea has the 7th largest automotive industry globally with 4.03 million vehicles produced in 2018
- Korea's CAV market is expected to be worth between GBP 700 million to GBP 2.5 billion by 2025
- Hyundai Motor Company has announced GBP 2 billion investment in CAV over the 5 years from 2019
- Key players in the CAV sector include Hyundai Motor Company, Hyundai Mobis, Samsung Electronics, LG Electronics, SK Telecom, KT and Naver Corp
- Korea's CAV industry currently excels in network capabilities, semiconductors and in-vehicle infotainment

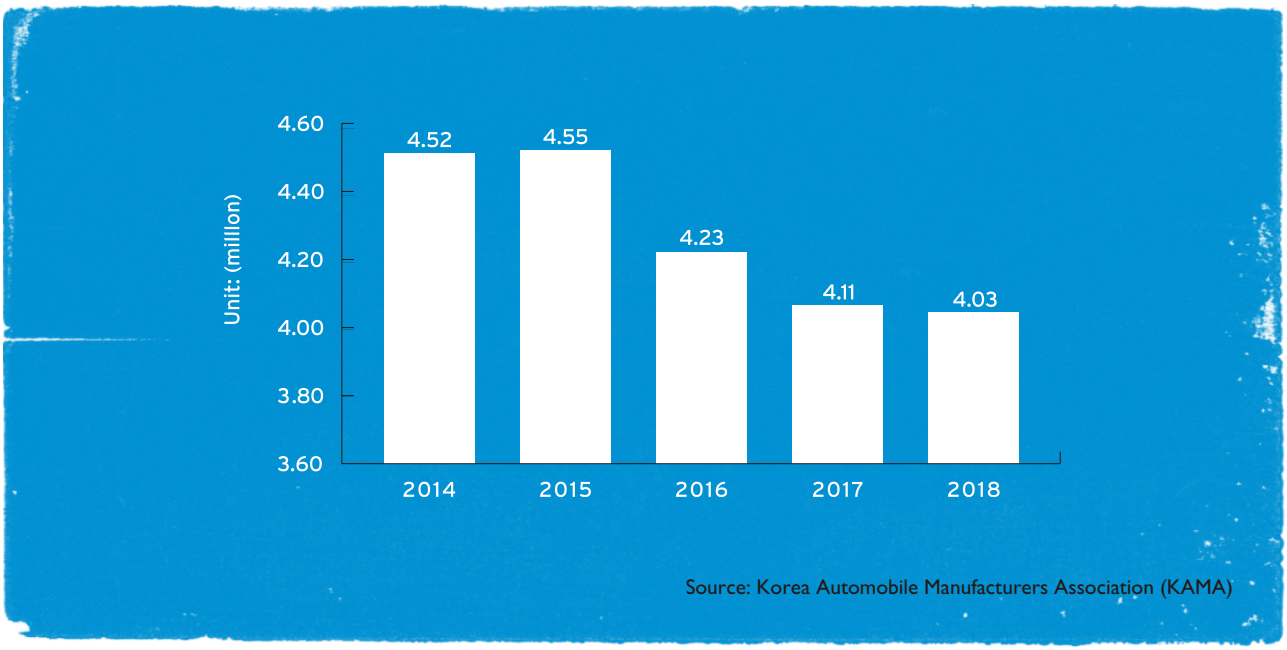
Korea has long been a powerhouse in automotive manufacturing and Korea produced 4.03 million vehicles in 2018. The country ranked 5th globally in terms of annual vehicle production until 2016 but currently ranks 7th after being overtaken by India in 2017 and Mexico in 2018. Korean OEMs traditionally dominated the domestic market, but over the past decade international carmakers have made strong inroads into the market with European luxury brands in particular having been successful at winning over Korean consumers. In 2018, non-Korean car brands accounted for roughly 18% of new vehicles sold in Korea and they have shown a CAGR of 5.2% over the period 2010-2018.

Connected and autonomous vehicles are a more recent phenomenon and started to attract the serious attention of the Korean government and private sector around 2016.

The Korean CAV market is in the early stages of development and its estimated size reached GBP 70-100 million in 2017. Projections by the Korea Institute for Science and Technology Information (KISTI) and Korea Telecom's (KT) economic research institute, Digieco, project a market size ranging from GBP 700 million to GBP 2.5 billion by 2025.

The Society of Automotive Engineers classifies autonomous vehicles in six levels of automation (level 0-5) with level 5 being full automation. The Korean market is currently in transition from partial automation (level 2) to conditional automation (level 3) and is actively developing related technologies, such as Autonomous Driver Assistance Systems (ADAS), Vehicle- to-everything (V2X), In-vehicle Infotainment (IVI) and high-definition mapping (HD mapping).

Figure 2: Domestically produced vehicles (2014-2018)



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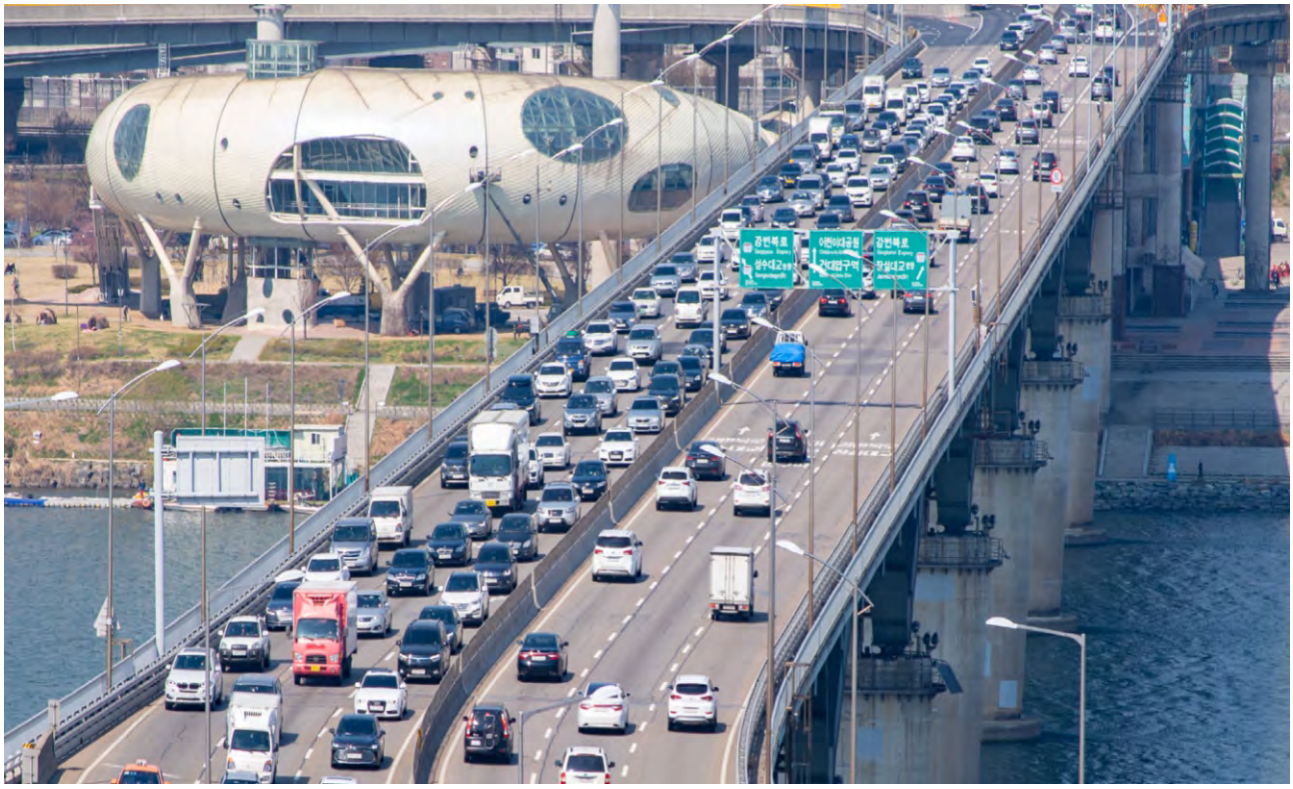
KOREA'S AUTOMOTIVE INDUSTRY



KEY PLAYERS

The automotive industry in Korea is dominated by Hyundai Motor Company which owns the Korean car brand Hyundai Motors and has a 33% share and effective control in Kia Motors. In 2015, the company created a new division, Genesis Motor, for its high- end vehicle brand, Genesis. The three brands that Hyundai Motor Company owns have a market share of approximately 70% in the domestic market in terms of vehicles sold, with imported cars and the three other domestic OEMs making up the rest of the automotive market in Korea. The other three traditionally Korean OEMs are Ssangyong Motors, Renault-Samsung Motors and GM Korea, although all of these are now controlled by foreign groups. Nearly 70% of the vehicles produced by the five Korean OEMs are sold overseas.

Hyundai Motor Company is the central part of the Hyundai Motor Group which, apart from the OEM, is comprised of a large web of Hyundai part suppliers that secure the company's supply chain. The most prominent one is Hyundai Mobis, which is one of the largest automotive tiers globally and supplies a variety of products to Hyundai Motor Company's brands including chassis, braking and steering systems, lamps, airbags and suspensions. Hyundai WIA (engines and axle modules), Hyundai Transys (transmissions, axles and seats) and Hyundai Steel (raw material) are other major affiliates of the Hyundai Motor Group that both heavily support and rely on Hyundai Motor Company.

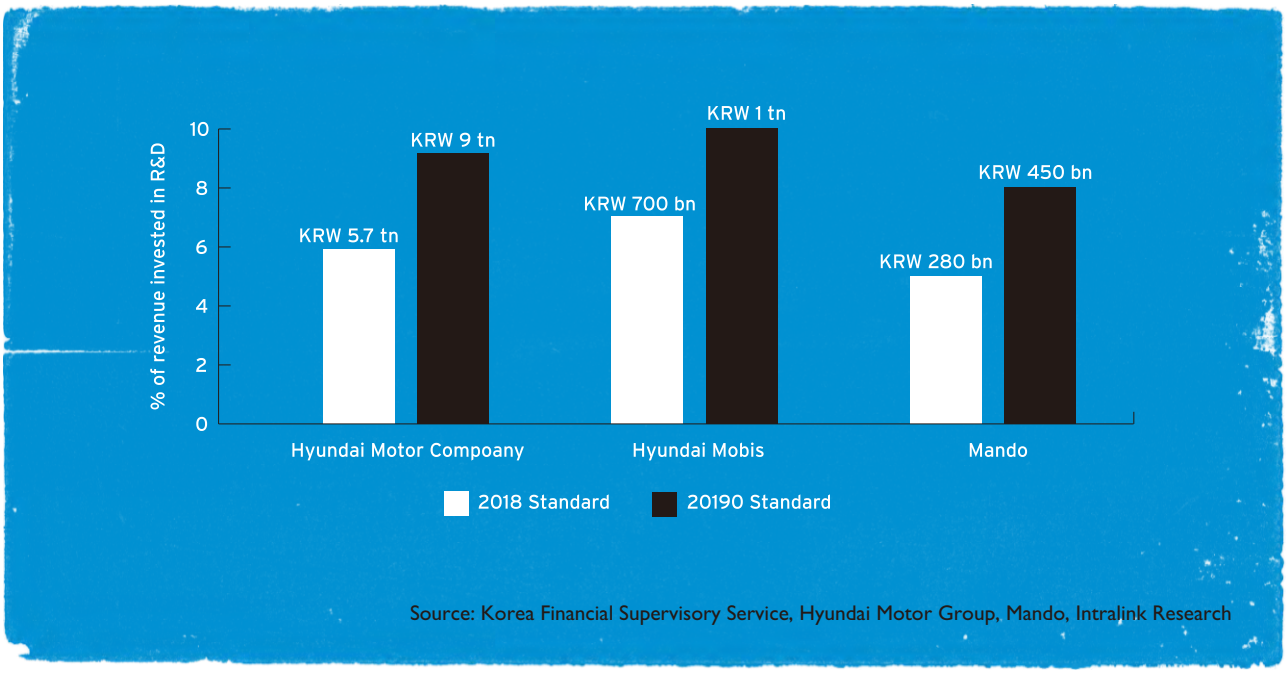
Apart from the Hyundai Motor Group affiliates, Hyundai Motor Company has a network of loyal tiers that it tightly controls.

The Korea Institute for Industrial Economics and Trade (KIET) calculated that sales to Hyundai Motor Company account for approximately 80% of the total sales of Korean tier suppliers. Two prominent tiers are Mando and Hanon Systems, both of which stem from Halla Group that was founded by the brother of former Hyundai Motor Group chairman, Chung Ju-Yung. Beyond this, there is a wide variety of substantial tiers that receive the lion's share of their GBP 1 billion plus revenue from Hyundai Motor Company, such as Seoyon E-Hwa, SL Corporation and Sungwoo Hitech.

R&D PIVOT TO FUTURE MOBILITY

Hyundai Motor Group's affiliates recently announced major R&D investments after steep declines in operating profit in 2018. The main reason for the difficulties were declining sales in both the US and China due to a lack of strategic anticipation in terms of increasing SUV demand. The company also responded to an increase in domestic labour costs by moving production facilities to Mexico and India.

Figure 3: Automotive Supplier R&D Investment



Source: Korea Financial Supervisory Service, Hyundai Motor Group, Mando, Intralink Research

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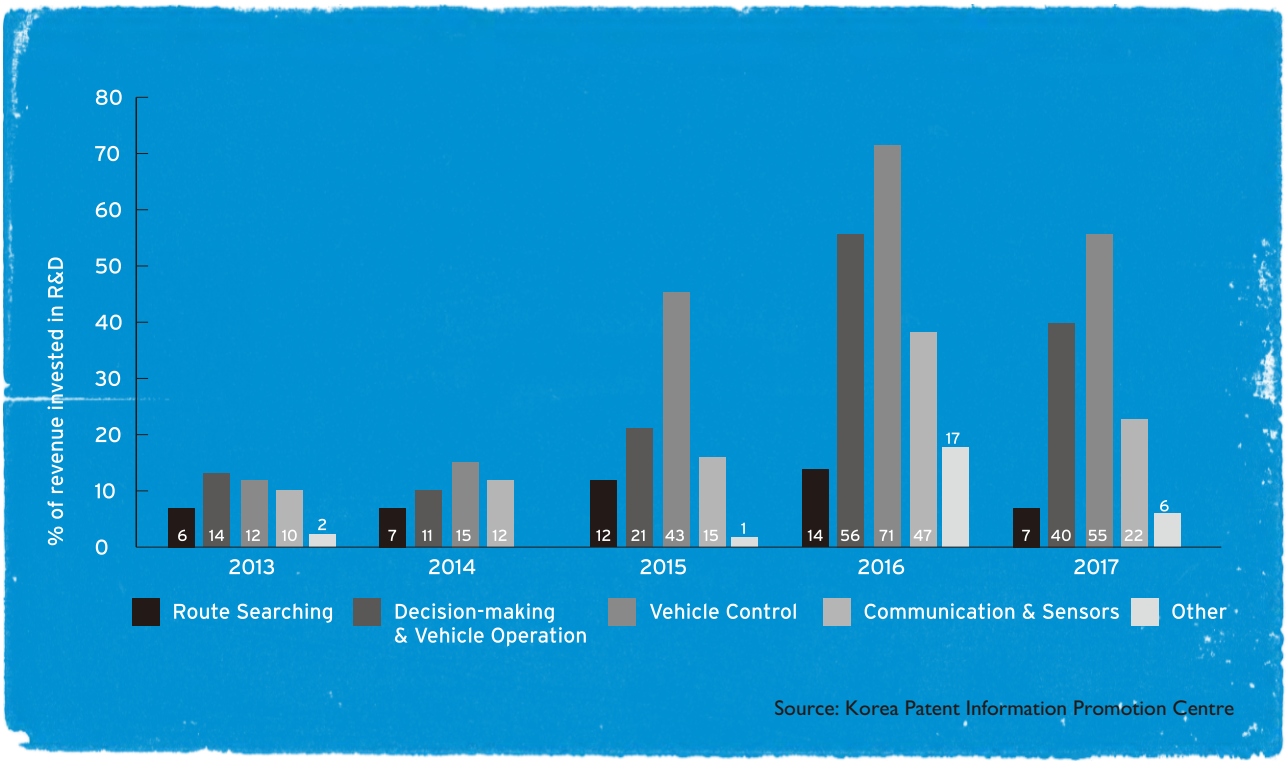
KOREA'S CAV ECOSYSTEM

Korea ranks 13th on KPMG's 2019 Autonomous Vehicles Readiness Index. Overall, the country ranks 4th in infrastructure, 7th in technology and innovation, 16th in policy and legislation and 19th in consumer acceptance. Particularly in terms of 4G coverage (1st) and number of AV-related patent applications per capita (2nd) Korea is a global leader, according to the index.

Indeed, Korea has seen a sharp increase in CAV-related patent registrations from 2015 onwards. Until that year, Korea had 129 registered patents that were related to CAVs but that number grew to 221 in 2015, 426 in 2016 and 556 in 2017. Patents related to vehicle control made up the largest share (39%), with decision and operation- related patents, and communication and sensor-related patents following in second and third place with 26% and 21% respectively (Figure 4). Korean conglomerates, including Hyundai Motor Company (92 registered patents), LG (60), Hyundai Mobis (27), Samsung (22) and Mando (13), filed 42% of the patents, with foreign entities (15%), research institutes (14%), SMEs (12%) and universities (11%) following the charge.

Figure 4: Korean CAV-related Patent Registration



KEY PLAYERS

Connected and autonomous vehicles are a perfect example of a convergence technology. They combine the automotive industry with the ICT industry – two of Korea's traditional strengths – and as such have created fertile ground for a number of traditionally strong players to expand their businesses, but also for new players to take the stage. Table 1 gives an overview of the industry leaders and their activity to date in the connected and autonomous vehicle sector.

Table 1: Key Players and their CAV Strategy

Company	Industry	Connected and Autonomous Vehicle Milestones
Hyundai Motors	Automotive	Engaged in partnerships with more than ten international CAV start-ups and announced GBP 2 billion investment in CAV technology until 2024
Hyundai Mobis	Automotive	Plans to employ 1,000 CAV engineers by 2021; opened GBP 200 million Seosan testing ground that includes radar and LiDAR test tracks in 2017
Mando	Automotive	Successfully tested a completely independently developed self-driving vehicle on public roads in 2019
Samsung Electronics	IT	GBP 6.4 billion acquisition of Harman International and creation of GBP 250 million connected and autonomous vehicle investment fund
LG Electronics	IT	Opened an R&D centre with Qualcomm for 5G V2X technology development; created a Vehicle Component Division with IVI as one of its primary focus areas
Naver	IT	Established R&D subsidiary "Naver Labs" which focuses its research on AI, robotics, and autonomous driving; plans on operating an AV taxi fleet
KT	Telecom	Developing C-V2X Technology with Hyundai Motors; Co- developed a self-driving bus for Incheon International Airport
SKT	Telecom	Engaged in a partnership with Intel, BMW and Mobileye to commercialise 5G-based CAVs by 2021

Source: Intralink Research

In terms of traditional automotive companies, Hyundai Motor Group leads the way for CAV development in Korea. Hyundai Motors has a dedicated connected and autonomous vehicle business division with over 400 engineers and Hyundai Mobis follows suit with divisions focusing on ADAS and IVI.

Hyundai's strategic partnership with US-based Aurora serves as the Korean carmaker's first and most prominent partnership in CAV to date, which was further strengthened after the June 2019 announcement of Hyundai acquiring a stake in the US start-up. Aurora works with automakers to design and develop a package of sensors, software and data services and is one of the leading CAV technology companies in the world. Hyundai Mobis' partnerships focus predominantly on sensors as is demonstrated by the company's investments in German start-ups SMS and ASTYX. The company further opened a testing ground in Seosan in 2017 that includes devoted CAV and radar test tracks.

Mando is another major traditional automotive tier supplier that operates a CAV division and constitutes a competitor for Hyundai Mobis, as well as an example of a Korean tier supplier that has broken loose from its dependency on Hyundai Motor Company. The company successfully conducted a level 4 autonomous driving test on the public road in February 2019 and has engaged in joint development projects with Tesla. It also has a permanent office at K-City, Korea's custom-built CAV testing ground, to facilitate its testing.

Local electronics giants are also venturing into connected and autonomous vehicle technology development. Samsung Electronics (Samsung) started its expansion into the CAV industry with its GBP 6.4 billion acquisition of Harman International in March 2017 and the announcement of a GBP 250 million CAV investment fund, with the takeover of Austrian automotive software provider TTTech representing the first investment under the fund. Samsung has been secretive about its CAV endeavours ever since but displayed an interactive cockpit for CAVs during ICE 2018 and more recently had its head of CAV announce in June 2019 that Samsung will strongly focus its CAV- related R&D on 5G-based hardware.

LG Electronics has a longer record in the CAV sector with a vehicle component division that was founded in 2013 after its acquisition of the EV engineering company V-ENS from its subsidiary LG CNS. The division focuses on IVI, 'Safety & Comfort', as well as EV solutions and is one of the five main business units that comprise LG Electronics. Both Samsung's and LG Electronics' automotive divisions have shown sharp growth with a 20% year-on-year increase in revenues in 2018 but are not yet profitable as the market is still maturing.

In terms of telecommunication companies, Korea has three major providers in SK Telecom (SKT) Korea Telecom (KT) and LG Uplus. The three companies simultaneously rolled out their 5G networks in April 2019, making Korea the first country globally to launch the next-generation network commercially beating the US, China and Japan. The leading position in 5G-technology development makes Korea an ideal hub for rapid CAV deployment and the telecom providers are investing heavily to secure their shares in this developing market.

KT already developed GiGA Drive IVI, a voice-recognition platform for connected cars that can communicate directions and driving conditions and has further announced it is creating '5G as a vehicle platform' (5GaVP), a 5G-based commercial self-driving system. SKT is engaged in a commercial project that will see the company work together with the Incheon Free Economic Zone to develop a smart city for 5G autonomous driving. SKT will build a high-definition map in the 130km2 zone that uses its '5G Dynamic Data Platform' for real-time updates and V2X communications. LG Uplus also recently announced Hanyang University completed a successful public road test in a highly-congested part of Seoul using LG Uplus' 5G network.

Two new players disrupting the traditional conglomerate-dominated ICT and automotive markets in Korea are domestic IT giants Naver Corp and Kakao Corp. Naver Corp (Naver) is predominantly known for its search engine, Naver, but also founded AI-focused subsidiary Naver Labs in 2013. Naver Labs was Korea's first company to be granted permission for AV public road testing in 2017. The company's strength is HD mapping, which it conducts by combining data collected from aerial images and its mobile mapping system 'R1' to reduce production costs whilst maintaining high accuracy. Naver Labs also has an IVI solution called AWAY, which was recently integrated into one of Korea's main car sharing platforms called Green Car.

Kakao Corp (Kakao) owns Korea's most popular mobile communications app called Kakao Talk. Kakao and Hyundai Motors' infotainment division announced a joint development project in 2017 which was completed in March 2019. Kakao's AI platform was implemented in Hyundai's latest Sonata model as an IVI system that has advanced voice-recognition capabilities and can provide assistance in navigation, climate control and playing music and videos, among other functions.

A large number of domestic start-ups are also coming up with innovative solutions to challenge the status quo, with Stradvision leading the pack. The company recently secured investments from LG Electronics and Hyundai Mobis to develop its deep learning-based vision processing software. Self-driving shuttle developer Unmanned Solution and HD mapping solution provider Carnavi are two other prominent start-ups in the Korean CAV sector.

Figure 5: Connected and Autonomous Vehicle Ecosystem

AREAS OF STRENGTH

Korea is renowned for its connected population and fast networks. Having topped the rankings for high-speed internet adoption and smartphone ownership for years, Korea is now a global frontrunner in areas such as 5G and the Internet of Things (IoT). With the combined effort of the government, telecommunication companies and network equipment and device manufacturers such as Samsung, Korea was the first country globally to launch a 5G network. The 2018 Pyeongchang Winter Olympics showcased the ICT infrastructure that Korea offers. The Olympics served as a commercial testbed not only for a 5G network, but Hyundai Motors also had a vehicle fleet drive the 150km from Seoul to Pyeongchang completely autonomously.

Korea further has a 58% global market share in memory semiconductors with Samsung and SK Hynix as sector leaders. Samsung has recently announced a shift in strategic focus toward non-memory and automotive semiconductors, with its partnership with Audi serving as a good example of this. Demand for high-performance system-on-chips (SOCs) is expected to increase as level 4-5 autonomous vehicles are highly dependent on them and need over 2,000 of chips to operate as opposed to the several hundred required in level 2-3 autonomous vehicles. A huge increase in demand for non-memory chips is anticipated for areas such as the numerous cameras and sensors that serve as the 'eyes' of autonomous vehicles.

In-vehicle infotainment represents another relative area of strength for Korea. Several companies have developed AI and IT-based systems and are constantly working on improving their solutions. LG Electronics' vehicle component division has a dedicated business unit for IVI solutions and Naver and Kakao boast advanced AI solutions, such as voice recognition and deep learning. Samsung Electronics' acquisition of connected car technology developer Harman International further strengthened Korea's capacity in this field.

Industry Insider's Thoughts

Korea has traditionally been very strong in hardware, such as semiconductors, but there is still room for improvement in LiDAR and radar technology.

Principal Engineer – Samsung Electronics

06

GOVERNMENT INITIATIVES

Key Points

- The Korean government has identified autonomous vehicles as a primary focus area for R&D efforts
- K-City is Korea's largest CAV testing ground with an area of 360,000m2
- The government is transforming Sejong city, Korea's administrative heart, into a "self-driving city" with a large CAV-exclusive area
- Other government projects include autonomous shuttle services in Pangyo and Daegu
- Moon Jae-In's administration has prioritised work on regulatory frameworks to support the industry

GOVERNMENT POLICY ON CAV

When President Moon Jae-In took office in May 2017 one of his main campaign promises was to stimulate the Korean economy by focusing on "innovative growth". The Moon Administration designated connected and autonomous vehicles as one of the thirteen focus areas for R&D for its five-year term and a significant budget has been made available to support the Korean CAV sector's development. Moon announced that businesses with a focus on the public domain, including transport, will receive preferential treatment for government support and designated self-driving buses, cargo vehicles, taxis and rental cars as specific target applications in this regard. 5G is a central theme of the Korean government's connected and autonomous vehicle strategy and all Korean expressways will be equipped with a 5G-based V2X network by 2022.

In line with this, the Ministry of Land, Infrastructure and Transport boosted its R&D support for connected and autonomous vehicles annually with the latest investment representing a 79% increase from GBP 2.8 million in 2018 to GBP 5 million in 2019. The Ministry of Science and ICT further selected automotive semiconductors as a strategic target sector and made available an investment budget of approximately GBP 10 million for 2019 to develop this core sector.

Perhaps the most visible government investment into connected and autonomous vehicles to date has been the GBP 8 million investment in the construction of K-City, a 360,000m2 testing ground for autonomous vehicles south of Seoul.

Construction of the facility started in June 2016 and was completed in November 2018. It was connected to a 5G network in early 2018, making it the first CAV testing ground globally to run on a 5G network. The test site recreates an environment with thirty-five different traffic situations through which self-driving cars can be tested. It includes toll gates, pedestrian and train-track crossings and even has potholes and construction sites. Both domestic and international entities can gain access to the ground. This includes an open data centre that stores data of tests that have been performed on the site.

Industry Insider's Thoughts

K-City has an open and non-discriminatory application policy for which international companies can apply as well. Moreover, companies that engage in partnerships with Korean SMEs or universities can be subject to favorable conditions.

Seong-Woo Cho – Head of Automated Vehicle Policy Division, K-City

In June 2019, the Seoul Metropolitan Government announced the opening of a public-road test bed for CAVs that is connected to a 5G network and is open to the public. The ground will be used for V2X network testing and the collection of public-road testing data. The facility further serves as a means to increase consumer acceptance of self-driving vehicles, an area to which the Korean government is dedicating increasing effort and resource.

Another recently implemented plan is the Korean government's '5G+ Strategy' that was announced in April 2019 and for which CAVs represent one of the five core 'service sectors'. Under the strategy, the Korean self-driving car sector will operate 5G self-driving shuttles in the cities of Pangyo and Daegu by 2020 and distribute 1,000 5G-equipped buses to local governments by 2025.

Traditionally an automotive parts supplier hub, the city of Daegu further announced an R&D support budget worth nearly GBP 100 million to stimulate the self-driving parts industry in the region from 2017 to 2022. Sejong, Korea's central administrative city, is another city at the centre of government CAV policy and will transform itself into a "self-driving city". Over the next five years, Sejong's centre will have a designated 2.74km2 area exclusively reserved for self-driving shuttles, shared vehicles and bicycles.

British autonomous pod developer Westfield Sportscars tapped into the Korean self-driving shuttle market as early as August 2017 with a GBP 30 million deal with North Gyeongsang province, demonstrating the significant opportunity this segment represents for British companies.

Table 2: Government-funded CAV Projects

Location	Project	Targeted Completion	Investment
K-City	CAV Testing Ground	2018	GBP 8 million
Seoul (Sangam)	CAV public test facility for data generation and consumer acceptance	2019	Unknown (joint effort with 17 private entities)
Daegu	Self-driving shuttles on 5G network, CAV- component hub	2020	GBP 100+ million
Pangyo	Self-driving shuttles on 5G network	2020	Unknown
Sejong	Exclusive CAV area in city centre with self-driving shuttles	2023	GBP 57 million

Source: Intralink Research

CAV-RELATED LEGISLATION

In November 2018, a government task force made up of representatives of the Ministry of Land, Infrastructure and Transport, the Ministry of Justice, the Office for Government Policy Coordination, the National Police Agency and various research institutes published a roadmap for regulatory reform for connected and autonomous vehicles. The roadmap identifies regulatory challenges for levels 3 to 5 of the Society of Automotive Engineers' (SAE) "Levels of Driving Automation" Standard and classifies the challenges into four categories: drivers, vehicles, vehicle operation and infrastructure (Table 4). The roadmap corresponds with the government's ambition to commercialise level 3 automation by 2020, level 4 automation by 2025 and level 5 automation after 2035.

Table 3: CAV Regulatory Reform Roadmap (2018)

	Level 3 anticipatory regulation (~2020)	Level 4 anticipatory regulation (2020~2025)	Level 5 anticipatory regulation (2025~2035)
Driver	• Inclusion of systems into the definition of "driver" • Permission to leave the driver seat when auto-parking • Mandatory system maintenance and inspection	• Lead-car requirements for flocking • Relaxation of driver warnings • Mandatory education for operating CAVs	• Simplified driver's licence requirements for CAVs • Relaxation of special driving restrictions, e.g. due to illness or overwork
Vehicle	• Improvement of definitions of various CAV functions • Preparation for CAV function safety standards • Improvement of system maintenance for CAVs	• Establishment of CAV-related accident registration system • Improvement of the MOT inspection system for CAVs	• Arrangement of certification framework for tuning AV systems and functions • Regulation for installation standards, e.g. seat plan
Vehicle Operation	• Establishment of civil and criminal liability framework for CAV-related accidents • Implementation of insurance regulation for damage reparation after CAV-related accidents	• Establishment of conditional requirements for flocking • Establishment of regulatory exemptions for flocking	• Arrangement of safety standards for CAV valet parking
Infrastructure	• Permission for location information and video image collection • Implementation of regulation for HD mapping by private entities	• V2X information provision method and maintenance standards • CAV system security standard • CAV infrastructure connection and management standards • Expansion of exclusive CAV areas	None as of yet

Source: Korea Office for Government Policy Coordination

In the short term, the Korean government takes redefining the term "driver" as one of the central points for regulatory reform and aims to include systems as vehicle operators in the Road Traffic Act by the end of 2019. The government already legalised driverless auto-parking in March 2018 and further plans to implement mandatory system maintenance and inspection regulations by 2020. Current regular system maintenance and inspection obligations for vehicle owners are not sufficient for connected and autonomous vehicles and the task force opted for including software updates as part of these periodic checks.

In terms of vehicle regulation, the government will further specify the definition of connected and autonomous vehicles and their functions and establish safety standards that will outline the production process and part requirements in greater detail by 2019. Another point of focus is the establishment of annual inspection and mandatory maintenance standards. The government further plans to amend regulations regarding civil and criminal liability for traffic accidents for cases where self-driving vehicles are involved by 2020 and intends to implement a suitable regulatory framework to ensure the insurance industry is able to adequately serve the industry as it grows.

A major reform that the task force has announced is granting permission for the collection of location information and video images without prior permission. Korea has very strict privacy standards, making these reforms a major breakthrough for CAV development. In April 2019, the National Assembly passed a legislation draft bill that addresses the outstanding short-term regulatory challenges and is expected to come into effect in April 2020.

Long-term regulatory reforms are more general in nature. Driver-focused regulation targets include mandatory education on operating a CAV by 2022 and eventually a CAV driver's licence by 2027. The government further aims to establish a system that registers CAV-related accidents by 2021. Maintenance standards for CAV infrastructure are another target that the Korean government aims to draft after 2020.

07 OPPORTUNITY AREAS FOR BRITISH COMPANIES

Key Points

- Key opportunities in Korea for UK CAV companies are autonomous driving technology, V2X & network communication, IVI and HD mapping
- Korean conglomerates are increasingly adopting an 'open innovation' approach and actively engaging in international partnerships
- Hyundai Motor is focused on sensors, such as low-cost LiDAR solutions and control software
- Samsung Electronics has announced automotive semiconductors and 5G-based V2X technology as strategic investment areas
- Telecom companies SKT and KT are developing C-V2X and HD mapping solutions, with IT players such as Naver and Kakao challenging them with their strong AI expertise

Through an analysis of recent announcements by the Korean government, investments within the private sector and one-on-one interviews with industry insiders, this report concludes there are ample opportunities for British companies in Korea's CAV industry. This section identifies three opportunity areas for British companies in the connected and autonomous vehicle sector: 1) Autonomous driving technology, 2) Vehicle- to-everything (V2X) & network communications and 3) In-Vehicle Infotainment (IVI) & HD mapping.

AUTONOMOUS DRIVING TECHNOLOGY

The development level of autonomous driving technology in Korea is currently between automation levels 2 and 3 of the SAE and the Korean government is targeting to commercialise level 3 automation by 2020.

ADAS technologies that will be commercialised by 2020 include highway driving assist (HAD), traffic jam assist (TJA), autonomous emergency braking systems (AEB) and auto parking systems (APS). Two ADAS technologies that Korean companies need to develop further to achieve short-term level 3 commercialisation are lane changing and intersection management solutions. British companies that possess innovative technology in these ADAS areas are likely to receive much interest from Korean automotive companies.

Autonomous driving technology is commonly divided into the three fields of 'perception', 'decision' and 'control'. A CAV's sensors such as cameras, radars and LiDARs fall under the field of perception, AI software and algorithms make the decisions and the vehicle's hardware, such as the electronic control units (ECU) and processors, control the vehicle.

The rest of this subsection will address the opportunities in the Korean autonomous driving technology segment according to these three fields.

Perception

About half the investments and strategic partnerships that Hyundai Motor Company engaged in 2018 relate to the field of perception. All-in-one sensor solution providers that combine LiDAR, radars and cameras, as well as low-cost LiDAR solution providers are expected to be target partners for Hyundai Motor Company and Hyundai Mobis. Hyundai Motors has partnered with US start-up Metawave and Israel start-up Opsys for this and Hyundai Mobis will develop advanced radars with German companies SMS and ASTYX.

Samsung Electronics might make its way into the sensor field as well. The company is rumoured to be working on combining the efforts of its mobile and automotive divisions and use its high-resolution IsoCell image sensor that was announced for mobile imaging in 2019 for automotive applications as well. The isolated pixel structure of the sensor makes it easier to deal with sudden contrasts in light, such as the situation of entering and exiting a tunnel. This alleged move into the field of automotive perception is a sign other projects might follow, so relevant British companies should look for opportunities with the Korean electronics manufacturer.

British companies are likely to receive interest from other automotive tiers, such as Mando, and IT companies, such as Naver and Kakao, as well in the field of perception. It is at the core of autonomous driving technology and many companies will look for strategic partnerships to enter this rapidly growing market. Indeed, Naver Labs recently announced the development of an image sensor based on deep learning and Korean start-up Unmanned Solution will integrate global market leader Velodyne's LiDAR into its vehicles.

Industry Insider's Thoughts

Mobis is particularly focusing on LiDAR as well as vision systems based on deep learning. If you have an innovative technology at the right price, every Korean OEM or tier, including Hyundai Mobis, will be interested in a partnership.

Seung-Wook Yang,
Former Executive Vice-President and Head of R&D – Hyundai Mobis

Decision

The Korean Commercialisation Promotion Agency for R&D Outcomes identifies the development of AI technology as a core challenge once Korea achieves commercialisation of automation level 3. The ability of 6vehicles to make independent decisions under complex circumstances, such as changing road surface and weather conditions are key in the transition from automation level 3 to level 4. Deep learning and human behaviour interpretation solutions are two specific opportunity areas for British companies in this regard.

Human behaviour interpretation can focus on the driver as well as other traffic participants. Solutions that can interpret a driver's physical and mental condition will help avoid accidents caused by driver fatigue or intoxication. Both Hyundai Motors and Hyundai Mobis engaged in a human behaviour interpretation focused partnership with Deepglint, a Chinese business that specialises in vision technology and has developed high-definition camera image recognition technology based on AI. Hyundai Motor Company also invested in Perceptive Automata, a company that takes sensor data to train deep learning models to interpret human behaviour. The result is artificial intelligence software that allows autonomous vehicles to anticipate the movements and actions of pedestrians, cyclists and motorists.

Samsung Electronics and LG Electronics have identified human behaviour interpretation and deep learning as potential growth areas for automotive applications and are both on the look-out for external solutions as well as developing in-house technology, as demonstrated by their patent registration record (Figure 4). Therefore, well-placed British companies are likely to find opportunities for joint development and licensing in the decision field in Korea.

Control

Hardware for vehicle control and especially non-memory semiconductors is an area that will see a significant increase in demand in the coming years in Korea. Indeed, automotive chips represented the fastest growing segment of semiconductors in 2018. Although Korea is a global leader in memory semiconductors, the country's non-memory semiconductor sector is not quite so competitive. The government has announced major investments to develop this sector and Samsung Electronics is also planning to focus in this area.

Analysts raise doubts over whether Samsung Electronics will be able to compete with more established names in the non-memory semiconductor and automotive semiconductor sectors, such as Intel. The main reason for the skepticism, as voiced by financial service provider SK Securities, is the Korean company's lack in expertise in terms of algorithm know-how and application processor design. Therefore, industry experts are anticipating major investments and large-scale acquisitions by Samsung in these two areas. SK Hynix seems satisfied with memory chips for the moment and although the company is developing automotive memory semiconductors, there are no signs it is looking to enter the non-memory chip market in the near future.

British companies that offer innovative and cost- effective design solutions in the non-memory processor segment are likely to receive a warm welcome from Samsung Electronics and possibly SK Hynix. Control software for autonomous vehicles is another area that represents significant opportunities for British companies looking to enter the Korean CAV market.

V2X & NETWORK COMMUNICATION

Vehicle-to-everything or V2X represents a core technology for connected and autonomous vehicles. The technology makes it possible for a car to communicate with its surroundings, including other cars (vehicle-to-vehicle, V2V), infrastructure (vehicle-to-infrastructure, V2I), networks (vehicle-to-network, V2N) and people (vehicle-to-pedestrian, V2P). The technology is essential to level 4 automation as it complements the 'eyes' of a vehicle. It further enables big data collection and processing that will help accelerate the transition between the different levels of automation.

There are two types of V2X communication: Dedicated Short-Range Communications (DSRC) and Cellular-V2X (C-V2X). DSRC was developed first and is WLAN-based. It uses underlying radio communication provided by 802.11p, an approved amendment for wireless access in vehicular environments (WAVE) to IEEE 802.11, the world's most widely used wireless computer networking standard. C-V2X, on the other hand, is based on LTE and has a native migration path to 5G. It supports wide area communication over a cellular network.

In Korea, both types of V2X have their supporters, with the automotive sector and MOLIT preferring DSRC and the MSICT and telecommunication companies preferring C-V2X. Hyundai Motor Company recently announced it will equip the newest Genesis G90 that will come to market in 2021 with DSRC, formalising its V2X path in the direction of DSRC. However, the company is also jointly developing C-V2X solutions with KT, simultaneously opening a path towards C-V2X. The carmaker explains its provisional choice for DSRC to be for reasons of stability, arguing C-V2X is a technology that is at earlier stages of development and that has no defined regulation standards yet.

Industry Insider's Thoughts

"There are no final decisions as of yet, but there are indications the Korean industry will move towards C-V2X.

Hyung-Sang Ryu, Smart Mobility Technology Team, Team Leader – LG Uplus

In line with its seemingly dual V2X approach, Hyundai Motor Company invested in Israeli start-up Autotalks, which has developed a dual-mode V2X chipset that supports both DSRC and C-V2X. Hyundai's public ambitions to make all cars connected by 2022 and commercialise automation level 4 by 2021 add weight to the opportunity that the company represents for British V2X companies.

C-V2X seems to be the preferred option for other major companies, with SKT and LG Electronics completing a successful V2X test base on LTE as early as 2017. LG Electronics' partnership with Qualcomm to develop 5G C-V2X technology serves as another example of Korea's maturity in this segment. In June 2019, KT completed the first 5G C-V2X test on a public road in Korea, adding strength to the argument that Korea is heading down the path of C-V2X, despite Hyundai's vote of confidence for DSRC.

V2X represents a major opportunity area for British companies that are active in this core segment of autonomous driving. Although Korean companies seem to prefer C-V2X, companies that offer solutions based on the DSRC standard might find a willing partner in Hyundai Motor Company or one of its affiliates. Korea's state-of-the-art 5G network and the government's plans to equip all expressways with 5G V2X capability by 2022 make the country an ideal target market for innovative British V2X businesses.

IVI & MAPPING

The In-vehicle Infotainment or IVI sector is relatively well-developed in Korea due to the country's strong electronics and IT sectors. Non-automotive companies tend to focus on IVI and the field is anticipated to experience exponential growth as the level of automation increases and automakers will focus less on driving and more on driver experience. The IVI sector consists of both software and hardware companies, with mapping and navigation companies given a separate subsection in this report since HD mapping represents an essential part of autonomous driving.

IVI

In-vehicle infotainment systems have been present for some time and are not necessarily related to connected and autonomous vehicles. IVI comprises a range of applications including playing audio or video content, navigation, games, internet access, weather updates and sport scores. The rapid development of network connections has drastically expanded and improved the set of IVI applications and the commercialisation of high levels of automation will accelerate this trend further.

The largest milestone for a Korean company in the IVI sector is the recent acquisition of Harman International by Samsung Electronics for over GBP 6 billion. The takeover was an aggressive move by Samsung Electronics into the automotive sector and the two companies have been working on an interactive digital cockpit for connected and autonomous vehicles, among other solutions. Samsung's partnership with Audi to integrate its Exynos memory chips in the German OEM's IVI systems is another way the company is tapping into the IVI sector.

Hyundai Motor Company has been integrating Google's Android Auto and Apple's Car Play into mass-production vehicles from 2016 onward, but the Hyundai Motor Group is lacking an affiliate that develops high-quality IVI systems. Both Hyundai Motor Company and Hyundai MnSoft have an IVI division but have thus far been unable to develop a satisfactory IVI system. Therefore, the carmaker started a joint development programme with Kakao Corp in 2017 that was completed in March 2019. Under the programme, the companies developed an IVI system that was integrated into the new Sonata model that was launched earlier this year. The system utilises Kakao's AI platform 'Kakao i' that has advanced voice recognition and natural language processing capabilities.

Korea's other IT giant, Naver Corp, is also active in the IVI sector. The company's AI subsidiary Naver Labs developed the IVI system 'AWAY' that was integrated into the fleet of Korean car sharing service company Green Car. The company's outstanding capability in the fields of machine learning, voice recognition and natural language processing provide solid ground for continuous development in this rapidly growing field.

British IVI companies are likely to find fertile ground for fruitful partnerships in the Korean IVI sector. The sector is advanced but consumer demand for continuous improvement is strong. The world-class 5G networks in Korea make the country a frontrunner in the IVI sector, so British IVI companies looking for international expansion should consider Korea as a steppingstone for further global expansion.

Mapping

High-definition mapping, 3D mapping and real-time navigation are three core aspects of autonomous driving. HD mapping and 3D mapping provide the data necessary for vehicles to navigate roads and essentially enable them to drive autonomously. Real-time navigation with live updates of traffic situations help vehicles select the optimal route and are crucial tools in reducing traffic congestion.

Telecommunication companies SK Telecom and KT are both developing high-precision, 3D maps to enable autonomous vehicles to roam the streets of Korea. SK Telecom has signed a contract with Incheon Free Economic Zone Korea, with telecom competitor KT not to develop a high- precision map of the zone that spans 132.9km2. The company partnered up with Dutch start-up HERE to develop its

mapping solutions and now leads the race in having made a public announcement of mapping solution development or investment just yet. Despite there being no formal indications, KT is expected to develop its own solution as well.

Naver Labs and Kakao Corp both have static mapping and navigation solutions in their portfolios and Naver Labs has already announced the development of a dynamic mapping solution for connected and autonomous vehicles. The company developed a unique HD mapping solution by combining data collected from aerial images and its mobile mapping system R1 to reduce production costs whilst maintaining high accuracy. The company will use the technology to map 2,000km of public roads in Seoul for connected and autonomous vehicles.

Kakao is a domestic static mapping market leader and entered into a partnership with British start- up What3Words earlier this year to adopt its revolutionary geo-coding system to maintain its competitive advantage as a market leader. Although Kakao has not formally announced the development of an HD map, the company has been included in a government consortium that is further comprised of other mapping market leaders SK Telecom and Naver and carmaker Hyundai Motor Company, raising speculations Kakao is working on an HD mapping solution behind closed doors. Hyundai MnSoft further deserves a mention as Hyundai Motor Group's mapping provider, but the company is facing tough competition from Naver and Kakao in terms of mapping capabilities.

HD and 3D mapping represent a core technology area for connected and autonomous vehicles and Korean telecommunication and IT companies, as well as government institutions, are making significant investments in this area. British companies offering cost- efficient mapping solutions will find capable partners in SK Telecom, KT, Naver and Kakao. Hyundai Motor Company or Hyundai MnSoft might also be open to partnerships to catch up with the domestic telecom and IT companies. Hyundai MnSoft's recent partnership with Netradyne serves as evidence for this.

Industry Insider's Thoughts

Hyundai MnSoft's main focus is mapping and the development of related software. We have invested a lot in HD mapping and are always on the lookout for new technologies.

Deok-Young Kim, Team Leader, Infotainment Team – Hyundai MnSoft

08

MARKET ENTRY STRATEGIES

Key Points

- Direct sales into the large conglomerates is possible but on-the-ground support is strongly advised
- Using a sales team based outside of Korea is difficult due to language and cultural barriers and very high expectations for after-sales support
- Partnering with local systems integrators or value-added reseller is advisable for foreign companies
- Foreign companies can apply to participate in government-led projects but there are barriers:
  - Culture, language, business environment, etc.
  - Preference towards local businesses adding at least some value to the products or services

Korea offers many opportunities for UK businesses with most Korean conglomerates actively investing in CAV- focused R&D and start-ups. The country hosts a rapidly developing local AV market and a highly developed ICT infrastructure which creates a solid foundation for foreign businesses to test and introduce their CAV technology.

However, UK businesses looking to engage in a strategic partnership or introduce their technology or product into Korea should take into account both business- related and cultural factors before setting out. UK businesses can approach the Korean market either through direct sales from the UK, by appointing a partner, or by setting up an office in Korea.

Direct Sales From the UK

The simplest market entry option is for UK companies to sell or license a particular CAV technology directly to Korean end-users. The main downside of a direct sales approach is the lack of local language and time-zone support as Korean companies tend to be particularly demanding of their partners. This can be mitigated by using a contract-based local liaison capable of bridging time-zone, language and cultural gaps without the long-term commitment of local incorporation and hiring. Market specific factors to consider include:

- Do we have a strong differentiator – something that sets us apart from our competitors in the market?

- Do we have a strong track record in other major markets? Korean companies are not easily convinced to use a new, disruptive technology as a first-mover without case studies
- Are we willing to localise the product for the market and/or for local regulations, if necessary?
- Are we ready to provide a Proof of Concept (PoC) at little or no cost to the customer? Korean companies will look to drive the price down and will not commit before proving the value through testing
- How do we provide after-sales support? Korean customers expect high-quality, local-language support

Appointing a partner

Perhaps a more common way to approach the market is to seek a partnership with an established local company that complements your product, has experience in the target sector and can help navigate the legal environment. A local channel partner, perhaps a systems integrator (SI), can provide services such as pre-sales, sales, consulting, installation, technical training, service maintenance, technical support and system integration in the Korean market. Even large multinationals usually take this route in the early stages of market entry. Market specific factors to consider when seeking a partner include:

- Does the partner already serve the type of customer that we do?
- Does the partner have a good understanding of the market in general and my particular application?
- Does the partner already offer solutions similar or synergistic to our offering?
- Is the partner focused on short-term wins or will they be able to drive our business in the long run?
- Does the partner have specific experience with public sector projects?
- Are we comfortable communicating with the local partner and are they transparent with us?

Establishing a Local Presence

There are broadly three ways of establishing a local presence: (1) a liaison office, (2) a branch office or (3) a local corporation through foreign direct investment (FDI). Setting up a liaison office is a simple process but a liaison office can only perform non-profit generating activities in Korea such as market surveys, research and development and quality assurance. Setting up a branch office can be a complicated process that requires specific documentation to be translated but it will allow for sales activities and the exchange of revenues with the head office. The most common process for an overseas company to open a branch office in Korea is through FDI where an initial investment is made by the head office which in return owns stock in the branch. The local corporation leads independent activities and is authorised to perform direct transactions. Market specific factors to consider when establishing a local presence in Korea include:

- Is our business generating enough revenue in Korea to consider a local presence? Businesses usually consider establishing a local presence after several years of sales (either direct or through a partner)
- Do we need to engage in profit generating activities, or not?
- Will we transfer staff from our head office or hire local staff? Both options have legal implications that need to be considered
- What location shall we pick for our local presence? Scouting, negotiating, and conclusion of contracts are very time-intensive processes that often are hard to conclude without local support

Whichever option UK companies select to enter the Korean market, these and other business and cultural considerations must be addressed and local support often proves to be invaluable in the market entry process.

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