



DISCOVER AUTONOMOUS DRIVING POTENTIAL IN JAPAN

REALIZE BUSINESS & COLLABORATION OPPORTUNITIES

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Japan's automotive industry is still playing catch-up in the field of autonomous driving and is likely to retake the lead within the coming years as it is a highly prioritized area for the government and companies alike. Swedish companies in automotive related industries with unique products or services should examine opportunities arising from Japan's ambitions within autonomous driving.

Japan has an Olympic dream - that Japan by the 2020 Tokyo Olympics will be able to amaze the world again by showcasing the future of travel; state-of-the-art self-driving cars. Only days prior to the first Tokyo Olympics in 1964 did the groundbreaking high-speed railway Shinkansen go into service. Shinkansen was able to reduce the duration of the trip between Tokyo and Osaka, Japan's two main economic centers, by more than 3 hours. The Olympic organizing committee has publicly stated that the 2020 Olympics is not only a sports event, but also an opportunity to showcase innovative technologies and a symbol for revitalizing the economy.

Despite being a leader in many industrial fields, Japanese companies still struggle to remain at the forefront of innovation in competition with international peers. The Japanese government has launched a Cross-ministerial Strategic Innovation Promotion Program (SIP) led by the Council for Science, Technology and Innovation. The program has identified 10 key areas to address the most pressing social problems and stimulate the Japanese economy, one of them being automated driving systems with 2.5 billion JPY invested in 2014, 2015 respectively and 2.7 billion in 2016. Investment plans of the government indicate similar levels of R&D spending annually through 2020.

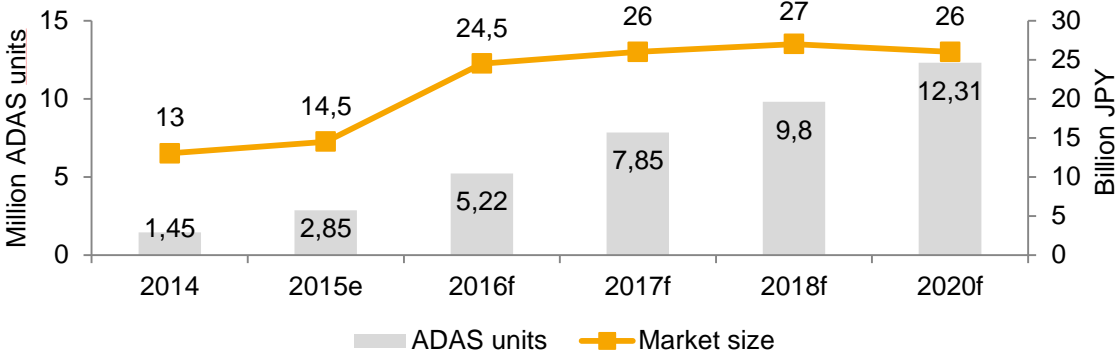
In a recent ranking of leading companies within the area of driverless technology there are no Japanese players. Instead are companies like Google, Volvo, Daimler, Tesla and Apple identified as the main frontrunners. The Ministry of Economy, Trade and Industry acknowledges that the government needs to implement policies to enable the Japanese automotive industry to compete with technologies of overseas competitors and that concepts like the internet of things, artificial intelligence and self-driving technologies are key to unleash the full transportation system potential.

The feeling that Japanese companies have fallen behind European and American automotive companies in the development of vehicle safety technology have increased incentives for Japanese companies to cooperate to prevent lagging behind also with regards to autonomous driving. This led to six major Japanese automotive companies and the Ministry of Economy, Trade and Industry (METI) signing an agreement to collaborate on autonomous driving in March 2016. The panel will focus on common shared key areas for the development of autonomous driving in Japan; 3-D maps, communication, standards, ergonomics to mention a few.

Key take-away: Japan's automotive industry is still playing catch-up in the field of autonomous driving, lacking pro-active involvement of tech giants similar to Apple and Google in the US. Absence of regulatory and collaborative frameworks and general public resistance to the technology are other reasons that have held

back development. Japan is likely to retake the lead within the coming years as it is a highly prioritized area for the government and companies alike. The automotive industry is a key national industry. All stakeholders seem willing to embrace collaboration on the basics to develop the next-generation of transport.

Figure 1 - Number of sold ADAS units & market size for ADAS in Japan 2014-2020 (forecast)



Source: Fuji Chimera Research Institute 2016

JAPAN IS LIKELY TO BE ONE OF THE MAIN DRIVERS OF DEVELOPMENT IN A RAPIDLY GROWING AUTONOMOUS DRIVING MARKET

The market size for self-driving car technologies in Japan is expected to grow rapidly over the coming years, projected to double already by 2017 from the 2014 level in nominal terms. The number of Advanced Driver Assistance Systems (ADAS¹) units in use is forecasted to increase by 8.5 times until 2020 from 2014 (the cost of one unit decreasing as the technology matures).

The global market for self-driving car technologies follows the same growth trend as in Japan². In number of units, the global market is expected to grow from 7 to 54 million units 2014-

2020. Japan's share of the total market stood at 20% in 2014 and is expected to increase slightly to 23% in 2020. Despite representing a major share of the total market, it is still less than Japanese automotive companies' car market share globally. 33% of all passenger cars produced in 2014 were produced by a Japanese company (30% if including commercial vehicles).

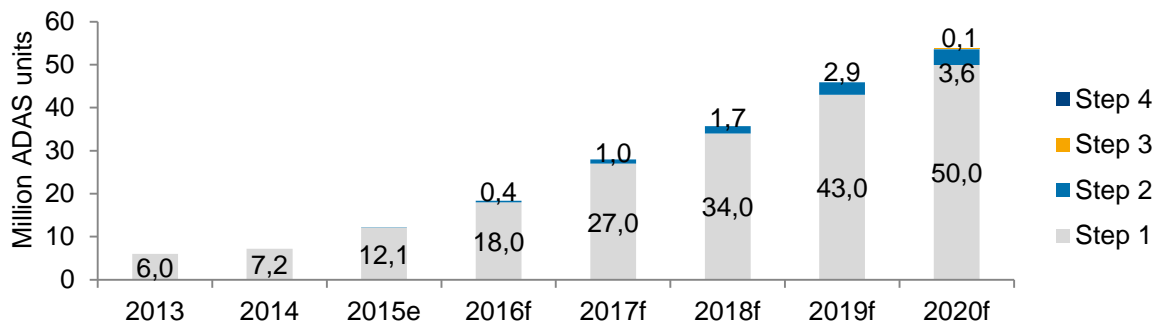
The global market for ADAS units is mainly made up by step 1 technologies until step 2 technologies are expected to take off in 2016 and beyond. Step 3 technologies are forecasted to make their commercial debut in 2020.

Key take-away: The market for automated driving systems is likely to grow rapidly in coming years. Japan is predicted to be one of the main markets and technology contributors.

¹ Advanced driver assistance systems (ADAS) are systems designed to avoid collisions by offering technologies that alert the driver to potential dangers, or to avoid collisions by safeguard. Adaptive features may automate lighting, adaptive cruise control, automate braking, incorporate GPS/ traffic warnings, alert driver to other cars or dangers, correct lane position, reveal blind spots etc.

² ADAS is a core technology that can be used to estimate the autonomous driving market size in the coming years, but it is less accurate for long term forecasts of the total automated driving market, as the price per unit is expected to decrease as the technology reaches maturity. The total market for automated driving systems, including related products and services, is expected continued growth

Figure 3 - Number of sold ADAS units globally 2014-2020 (forecast)



Source: Fuji Chimera Research Institute 2016

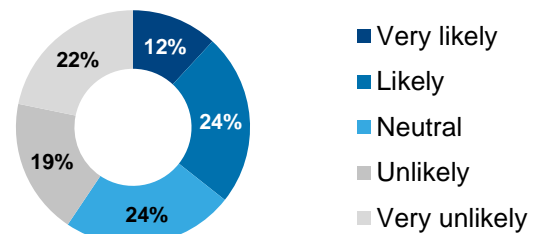
OUTSTANDING ISSUES ARE UNIVERSIAL & NEED SOLUTIONS FOR WIDESPREAD USAGE

Major outstanding issues standing in the way for implementation of automated driving technology are basically universal and nothing unique for Japan. Main issues to be resolved are:

- ▶ To make the technology safe enough to implement. The necessary technology is already available but is in need of extensive testing in real life environments.
- ▶ To draw up a regulatory framework outlining the legal responsibility in case of an accident, anti-hacking measurements, modifications of driver's licenses etc.
- ▶ Maybe the largest challenge is the risk of people not accepting having driverless cars on the streets as they don't trust the technology.

According to a recent survey by major insurance companies, many Japanese consumers still have concerns about autonomous driving. 52% were not confident to drive an autonomous driving vehicle. 51% were worried of driving in congested areas with automated systems. Consumers also had concerns whether a driver is able to take the necessary emergency actions when the autonomous driving system requests the driver to do so. In this regard are Japanese consumers more cautious towards the technology than peers in e.g. China, the United States or Germany.

Figure 4 - Consumer attitudes in Japan, % of respondents likely/unlikely to try a self-driving car



Source: World Economic Forum 2015

Key take-away: Japanese automotive companies will play a pivotal role in the commercialization and implementation of step 2 and step 3 technologies that will make up the main part of the automated driving system market for years to come. Even if the above mentioned survey indicates that the Japanese consumers are less willing to try self-driving cars, the study focuses on the notion of step 4 fully automated driving without active monitoring by a driver. Japanese consumers are always looking for the latest gadgets and are used to high-tech innovations in their daily lives, not only when it comes to cars, and there is significantly less (if any) resistance towards driver assistance monitoring systems (i.e. step 1 & 2).

MULTIPLE DRIVERS BEHIND THE MARKET FOR AUTONOMOUS DRIVING IN JAPAN

The main drivers behind the development of autonomous driving in Japan are:

a) Achieving national goals

- ▶ Traffic safety – autonomous driving has the potential to improve traffic safety. 90% of all accidents are said to be caused by human error. Japan has a relatively low number of traffic related fatalities (32 per million inhabitants or 4.117 fatalities in 2015, cf. Sweden 28 per million). The Japanese government is promoting ICT and telematics in cars. Automated braking, spatial indications and the usage of other cars' information to prevent accidents are prioritized.
- ▶ Reducing costs for society – mainly three societal costs are expected to be significantly lowered by extensively introducing automated driving systems. Firstly, fatalities and damages as a result of increased traffic safety. Secondly, environmental pollution by improving fuel efficiency. And third, lessened time loss due to traffic congestion by driving efficiently, reducing inter-vehicle space and being able to choose the most appropriate driving route etc.
- ▶ Tokyo 2020 Olympics – Japan astonished the world at the 1964 Olympics, displaying remarkable post-war progress. Once again, Japan has the ambition to showcase innovative technologies and a revitalized economy. Implementing the next-generation public transportation system would be a key milestone.

b) Addressing social issues

- ▶ Aging population – a majority of fatal accidents is caused by elderly drivers (one quarter of all accidents in 2014 leading to fatalities were caused by drivers 65 years or older). A majority of the fatalities (55%) were aged 65 or older. Elderly people living in rural areas also suffer from lack of public transportation in depopulated areas. The society as a whole would benefit from increasing the mobility of elderly people, while increasing the safety and keeping the

aging population behind the wheel for longer, which will boost the automotive industry.

- ▶ Shrinking workforce – less labor available to drive taxis, buses etc.
- c) Stimulating the economy
 - ▶ Industry competitiveness – an effort to stimulate the economy by aspiring to become world-leading within automated driving, strengthening the automotive industry's competitiveness and increasing high-value added exports.

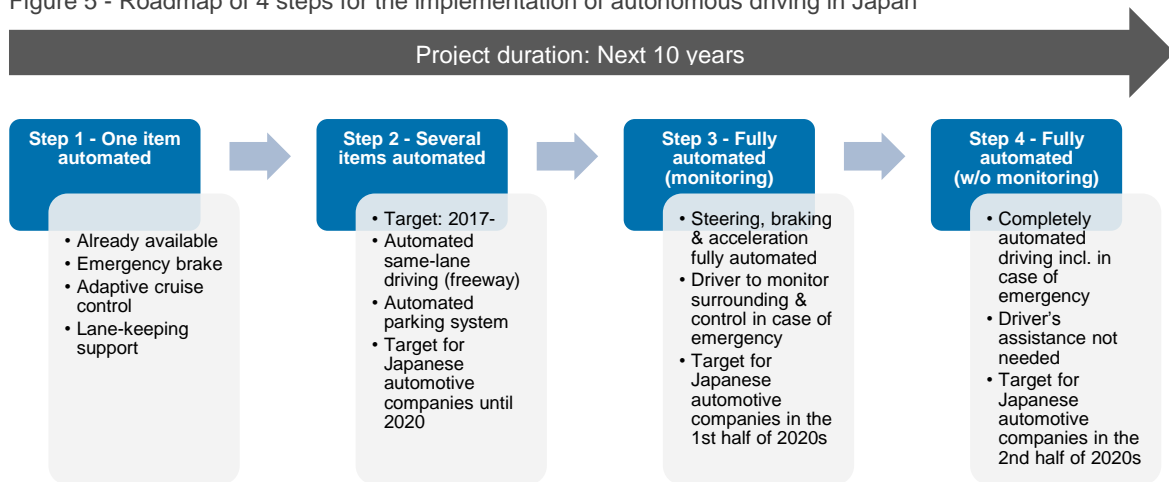
Key take-away: The main drivers for automated driving development in Japan are to increase traffic safety and address problems associated with the aging population. As the population is getting older, Japan needs to keep the aging population behind the wheels for longer while upholding traffic safety. Japan is an interesting testing ground for autonomous driving due to different driver behavior and road conditions (narrow roads, blind corners, rural areas etc.).

THE JAPANESE ROADMAP TO AUTONOMOUS DRIVING HIGHLIGHT IMPORTANCE OF STEP 2 & STEP 3 TECHNOLOGIES BEYOND 2020

The Japanese definition of autonomous driving is largely identical to international definitions. Autonomous driving is basically a vehicle that is capable of sensing its environment and navigating without human input. One term often used in Japan is Intelligent Transport Systems (ITS), systems to increase traffic safety, decrease congestion and emissions by using information technology, e.g. Vehicle Information and Communication System (VICS) and Electronic Toll Collection (ETC). ADAS is another term used specifically referring to technologies able to reconnaissance a vehicle's surroundings, health condition of the driver, receiving real-time navigation information.

Four steps have been outlined for the realization of autonomous driving in Japan: Step 1) One item automated, Step 2) Several items automated, Step 3) Fully automated (monitoring) and Step 4) Fully automated (without monitoring). Japan is currently lagging behind to reach Step 3 by early 2020s. Dynamic 3-D maps and Vehicle-to-everything (V2X) communication being key technologies to its implementation.

Figure 5 - Roadmap of 4 steps for the implementation of autonomous driving in Japan



Source: Society of Automotive Engineers in Japan, 2016

Japan's National Police Agency (NPA) announced draft guidelines for autonomous driving on public roads on April 6th, 2016. The guidelines state that a driver (with driver's license) should monitor surroundings and take necessary actions in case of an emergency. The driver is to be held responsible in case of a traffic accident. All testing should follow relevant existing regulation, such as the Road Traffic Act. The Road Trucking Vehicle Act is also to be amended to cover autonomous driving.

Japan is already adhering to international standards for some key technologies, such as emergency braking, adaptive cruise control and lane-keeping support. Further agreements are expected between Europe and Japan/Korea, while the United States' intention is to introduce own standards.

Japanese automotive companies and METI have formalized collaboration in the form of a study panel, consisting of Toyota, Nissan, Honda, Denso, Renesas Electronics and Panasonic. The panel will focus on common key areas for the development of autonomous driving in Japan; 3-D maps, communication, standards, etc. A blueprint is to be published in March 2017 to outline the framework for the development until 2020 and beyond. A 3.4 billion JPY test track for self-driving cars is also to be operational in 2017.

The eight biggest Japanese automotive companies indicated R&D investments of almost 3 trillion yen in fiscal year 2016 (ending March), which is a record amount. One main challenge is for example to attract key individuals specializing

in communication, artificial intelligence and recognition technologies. Both Toyota and Honda have recently opened R&D centers in Silicon Valley in an attempt to increase exposure towards crucial key competence professionals.

Other recent developments include:

- ▶ Nissan launched minivan model "SERENA" in August 2016 with a step 2 function called "ProPILOT". The function features same lane automated driving when driving on a freeway.
- ▶ Hino Motors and Isuzu Motors signed an agreement regarding joint development of ITS technologies for autonomous driving for trucks in June 2016. Technologies include; formation driving (minimum 4 meter gap), lane keeping, gap keeping (minimum 4 meter gap), collision avoidance and front vehicle following.
- ▶ Electric components manufacturer Omron announced in June 2016 that it had developed a sensor that can sense the driver's concentration level while driving using AI technology.

Key take-away: Japan and the United States point out the importance of building the necessary infrastructure for connected vehicles, as both countries acknowledge this as key to realizing higher levels of automation. But there are different attitudes between car manufacturers mainly in Japan/Europe and IT companies in the US. While leading American IT companies are interested in continuously expanding the technological boundaries, car manufacturers

tend to have concerns about their role in a fully-automated-driving society. Car manufacturers do not necessarily see step 4 as the ultimate goal, but focus rather on business opportunities in step 2 and 3 technologies. There is a belief that the purchasing behavior of fully automated vehicles is radically different from ordinary car sales, not taking into account the driver's experience etc.

THERE ARE INTERESTING TECHNOLOGY COLLABORATION OPPORTUNITIES FOR LEADING SWEDISH COMPANIES IN JAPAN

There are both business and collaboration opportunities with Japanese companies as the domestic automotive industry is still lagging behind to reach the third step of the automated driving roadmap. The Japanese market is highly interesting with a large automotive manufacturing industry and also from a research collaboration perspective. There is awareness in Japan of the autonomous driving progress in Sweden.

Japanese automotive companies are keen to follow developments within this area in Sweden, especially the collaboration between companies, academia and government in Gothenburg.

Japan has long lacked sufficient regulatory and collaborative framework to develop autonomous driving infrastructure. Now all stakeholders seem willing to embrace collaboration. The Cross-ministerial SIP-program is a key player in this pursuit together with Intelligent Transport System Japan (ITS Japan). SIP is fundamental for the overall framework while ITS Japan is involved in research, construction of new infrastructure systems and foster demand for many types of terminal equipment on a national safety level. Additionally are other government bodies, academia & research organizations, automotive manufacturers, technology providers, electronics & component manufacturers etc. all involved in the development of the next-generation of transportation in Japan. Several of these are reaching out for collaboration with international (mainly European) counterparts.

The Japanese market has never been (and still isn't) an easy market for foreign companies to operate in, but it can be very rewarding as long

as you dedicate enough attention to the market. And there are signs that the market is becoming more easily accessible. There is a changing attitude towards international business practices and increased openness towards foreign collaboration. This has been highlighted by Nissan Motors recently announcing a move towards working more closely with international leading suppliers, rather than relying on traditional keiretsu supplier relationships in an effort to remain internationally competitive is one example of a changing business environment.

Swedish companies in automotive related industries with unique products or services should examine opportunities arising from Japan's ambition to retake the lead within automated driving systems and the development of the next generation of transport systems. Of potential interest to Japanese companies are products and services relating to data, security, communication and sensors. These are some identified potential areas of collaboration:

- ▶ Technologies for data & security
 - Know-how on making dynamic maps utilizing big data
 - Information security for V2X technologies
- ▶ Technology for communication
 - Vehicle-to-vehicle (V2V)
 - Vehicle-to-everything (V2X)
- ▶ Sensor technologies
 - Sensing condition and actions of driver
 - Sensing other vehicles
 - Radar technologies, able to detect obstacles in foggy/bad weather condition

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