AI, ROBOTICS AND MOBILITY AS A SERVICE: THE CASE OF SINGAPORE

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KEYWORDS

- AUTONOMOUS
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INTRODUCTION

With a land area of 719 square kilometers and a population of 5.61 million (as of June 2016), Singapore is known to be one of the most densely populated country in the world. 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 demand to set aside land for housing, infrastructure, and amenities is expected to rise. While tools such as the vehicle quota system and road pricing system to control vehicle growth and manage road congestion have proven to be effective thus far, it is unlikely that these strategies can continue to sustain future needs.

Physical constraints also coincide with economic needs to be a more service-based economy, and the government has announced its plans to be a "Smart Nation" that leverages advances in digital technology to create a more liveable, innovative, and economically city. Five key domains have been identities – transport, home and environment, business productivity, health and enabled aging, and public sector services – as areas where technology can drive impactful solutions to address current and future challenges.

Economic needs under severe physical constraints have prompted Singapore to be an active adopter of the autonomous vehicle. Since 2014, Singapore set up the Committee on Autonomous Road Transport in Singapore (CARTS) to study autonomous vehicle applications, as well as regulations and implementation. From the onset, four application areas were identified: (1) fixed and scheduled services for efficient mass transportation, (2) point-to-point or mobility-on-demand services, (3) freight, and (4) utility operations.

Singapore is noted for being one of the first movers in embracing self-driving cars, but it also possesses natural advantages in doing so. The city-state's high urban density, limited workforce for commercial drivers, knowledge-based economy, modern infrastructure, efficient government, and a highly educated population makes it an attractive place to develop innovations in self-driving car technologies. With the insights gained from testing and evaluation of self-driving car technologies in collaboration with the private industry, Singapore is well-positioned to be a potential role model country in land transportation transformation and "smart town design of the future".

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STRIVING FOR MOBILITY UNDER LAND CONSTRAINTS

Singapore's plan for autonomous vehicles is unique in many ways. Firstly, Singapore continues to value public transportation for mass commute and does not view that the introduction of autonomous vehicles will render public transit obsolete in the near to mid-term. The city-state envisions autonomous vehicles to be employed as a complementary means of public transportation e.g., autonomous buses, for first-mile and last-mile travelling. Secondly, Singapore does not intend for autonomous vehicles as a direct replacement for human-driven cars; rather, the focus is on mobility as a service via ride-sharing and car-sharing.

Thirdly, Singapore is application-specific but remains technology-agnostic, partly because while Singapore is one of the first movers to embrace autonomous vehicle capabilities, the comparatively small size of the potential market limits her leverage to drive the technological decisions of manufacturers and developers. From the technological perspective, the highly build-up urban areas in Singapore may create urban canyons that limit the effectiveness of localization technologies. In addition, city driving is viewed as one of the more challenging tasks for self-driving cars. The ever-changing street map (e.g. pedestrians, cyclists, urban features) and stop-and-go traffic in a city environment may demand more advanced perception and sense-making technologies.

Nonetheless, Singapore remains an ideal option to implement self-driving cars. The Singapore government is a strong advocate for technology and innovation, and continues to attract high-tech talent and investments in high-end research and development. Next, Singapore has a robust physical and communications infrastructure, which are essential ingredients to enable test, evaluation and operationalization of self-driving cars. Furthermore, with the intent to alleviate the labour shortage for bus drivers in Singapore, autonomous buses can be deployed for first-mile and last-mile commuting. With possibly shorter headway between autonomous vehicles when coupled with V2V and V2I connectivity, road congestion may be alleviated if the number of vehicles on the road remains constant. In the long term, the concept of autonomous vehicles for transportation as a service may encourage car-sharing and ride-sharing behaviors, which favors Singapore's intent to control the number of vehicles on the road.

CURRENT LANDSCAPE

Private investments in autonomous vehicle developments have grown since the mid-2000s, and continue to accelerate today. The attractiveness of the potential benefits to be reaped from autonomous vehicle market has influenced the entry of new players and prompted existing players to move into new business areas. The vehicle marketplace is no longer solely dominated by the traditional automotive manufacturers. In recent years, we have witnessed the entry of new players ranging from technology developers to Tier-1 suppliers and even ride-sharing service providers. The traditional carmakers are also seen attempting to venture into the ride-sharing business.

At present, it is uncertain which market player will emerge as the ultimate winner, nor is it apparent on which technological pathway is the winning concept. With strong interdependencies among the technologies that enable autonomous driving, a diverse suite of technical expertise coupled with significant investment are essential, thus it is almost impossible or too risky for a single entity to develop it alone. In terms of deployment timeline, several market players have indicated the desire to launch a highly automated or fully autonomous vehicle by 2020.

In Singapore, several initiatives have been established between the government, research, academic, and industry communities. In August 2014, the LTA signed a Memorandum of Understanding (MOU) with the Agency for Science, Technology and Research (A*STAR), a

public sector agency that spearheads economic-oriented research, to jointly set up the Singapore Autonomous Vehicle Initiative (SAVI). The SAVI serves as a platform to oversee and manage research and development, and test-bedding of autonomous vehicle technologies, applications and solutions for industry partners and stakeholders. In January 2015, the LTA announced that the one-north district in Singapore as the first test site for autonomous vehicle technologies and mobility concepts. The test route was doubled from the original 6km to a 12km network in September 2016. As of October 2016, there were four distinct entities conducting autonomous vehicle proof-of-concept tests at the test site. In June 2015, LTA issued a Request for Information (RFI) to seek proposals on how autonomous vehicle technology could be harnessed as part of other land transport mobility concepts, such as mobility-on-demand and autonomous buses. The RFI also sought to understand the requirements, such as road and communications infrastructure, that are necessary to enable implementation of autonomous vehicle enabled mobility concepts in Singapore. Eight proposals were received in response to the RFI and the evaluation outcomes are progressively being released. In October 2015, a MOU was signed between the MOT and the Port of Singapore Authority to jointly develop autonomous truck platooning technology for transporting cargo between port terminals. The MOT also signed another MOU with Sentosa Development Corporation and Singapore Technologies Engineering Ltd to trial self-driving shuttle services across Sentosa.

In August 2016, LTA established a partnership with nuTonomy to test their shared, on-demand, door-to-door, first and-last-mile, and intra-town self-driving transportation concepts in one-north. In addition, nuTonomy also partnered Grab, a leading ride-hailing app in Southeast Asia in September 2016. The LTA also established a partnership agreement with Delphi Automotive Systems in August 2016. Delphi is one of the major Tier 1 supplier of vehicle technologies, and they will develop and test a fleet of fully autonomous vehicles including a cloud-based mobility-on-demand software suite at one-north. In October 2016, the LTA also announced partnership with the Energy Research Institute @ NTU, to develop autonomous bus technologies, which included a self-driving bus trial for fixed and scheduled services for intra and inter-town travel. The LTA and JTC also partnered with NTU to launch the Centre of Excellence for Testing and Research of Autonomous Vehicles - NTU (CETRAN) and test circuit at CleanTech Park in the Jurong Innovation District in August 2016. CETRAN

will spearhead the development of testing requirements for self-driving vehicles, and the test circuit will provide a simulated road environment for testing of the vehicles prior to deployment on public roads. As part of the five-year agreement with LTA, NTU will lead the research activities at CETRAN, collaborate with international testing, inspection and certification bodies, research institutions and industry, operate the test circuit, and evaluate the self-driving vehicle prototypes that are tested. The test circuit is expected to be operational by the second half of 2017.

TECHNOLOGICAL CONSTRAINTS AND OPPORTUNITIES AS SEEN IN SINGAPORE

As a city-state, Singapore has high population density. The country has been blessed with warm but stable weather, making it easier to test technology, but its high skyscrapers, underground tunnels, and extensive planting present challenges to sensor technologies. To realize capabilities in Autonomous Vehicle (AV), there needs to be a convergence of technologies in *perception, navigation, localization, sense-making and telematics*. At present, despite heavy investments in the ecosystem it is uncertain which technological pathway is the clear path forward.

a. Perception refers to the ability of the AV to sense its complex and dynamic driving environment. AVs typically have a suite of perception sensors, software that blends the sensors data from these, and further software that analyzes this information to enable the vehicle to perceive and sense-make in different environments.

b. Navigation and localization work in tandem to guide a robot from place to place. Navigational accuracy refers to the precision with which the autonomous vehicle can guide itself from one point to another. Localization accuracy is a measure of how well the vehicle locates itself within a map. Localization appears to present the greater challenges.

c. Sense-making refers to the process of understanding and interpreting the voluminous data the sensors on the AV collect continuously. AVs need to learn from their environment to decide the next course of action with little or no human intervention. Artificial intelligence plays a key role in this process.

d. Telematics combines wireless communications, information management, and in-vehicle computing to enable exchange of information. It enables AVs to continually update the state of their environment. Proposed AV systems particularly suppose that individual AVs will connect both with each other and the environment. They would use different communication technologies to communicate with the driver, other cars on the road (Vehicle-to-Vehicle, V2V), roadside infrastructure (Vehicle-to-Infrastructure, V2I), and the "Cloud".

CONCERNS TO JOBS

In terms of societal cost, there is a risk that certain jobs (e.g., taxi drivers, bus drivers, parking attendants, and valet parking attendants) could be eliminated or restructured as autonomous vehicles become prevalent. In addition, the revenue that the government collects from road taxes, parking fees, speeding fines, and incident management costs could be affected. Policymakerhave begun to examine how individuals in the affected job roles can be redeployed or retrained, as well as to review the current revenue mechanisms.

There are currently few schemes to address specifically the job loss that can result from autonomous vehicles, in part because the Ministry of Transport reckons that the full adoption of AV will occur only in about 10-15 years.[1] Dealing with job displacement therefore takes a more holistic approach towards both slow growth and a rapidly digitizing service economy. The government has announced the all-ranging SkillsFuture initiative, to provide Singaporeans with different types of training in order to adapt to different skills that employers require. As attested on the website, regardless of "where you are in life – schooling years, early career, mid-career or silver years – you will find a variety of resources to help you attain mastery of skills." Beyond re-training for citizens, the government actively assists companies in digitizing their operations in order to improve productivity and hence better scale up operations and hire more workers. The iSprint initiative announced since 2010 has helped 8000 SMEs improve their businesses through technological innovations.

Most recently, the government has pledged $100 million to the Global Innovation Alliance, a scheme to help Singaporeans gain skills to better find work abroad, and the new SkillsFuture Leadership Development Initiative, which provides specialized training for Singaporeans to better reach leadership positions in companies. The government has also accepted the recommendations by the Committee of Future Economy to focus on helping citizens better acquire "deep skills", with the government facilitating the matching between skills and employment—the setting up of IMDA's TechSkills Accelerator (TeSA) and a national jobs bank both aim to serve these functions of creating better employment opportunities for Singaporeans

GOING FORWARD

Singapore's journey into Autonomous vehicles plays into the city-state's natural advantages in climate, skills, modern infrastructure, and efficient government bureaucracy. Being the first-mover has attracted much buzz and excitement, especially with nuTonomy's test-drives in the One-North area, which is the first of its kind in autonomous vehicle testing in real-world city environments. However, the first-mover advantage might also be soon met with critical realities such as uncertainty over technological solutions, competition with traditional transport operators, or the loss of jobs for the most vulnerable citizens.

Nevertheless, unlike most autonomous pilots abroad, there is concerted coordination in Singapore between government, research agencies, and industry to get autonomous vehicles off the ground. Deep partnerships are essential for the autonomous vehicle to actualize the vision of a "Smart Nation", and the little city-state is seemingly on the right track to drive the technology forward. But its success will eventually lie in the adaptability of this stakeholders to adapt to changing needs of the economy and the underlying technology, without forgetting that the true adopters of the autonomous vehicle will be its citizens, who need to be adequately empowered and have fears allayed in order to fully embrace this groundbreaking technology.

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1 https://www.imda.gov.sg/infocomm-and-media-news/whats-trending/2017/2/driverless-cars-picking-up-speed-in-singapore