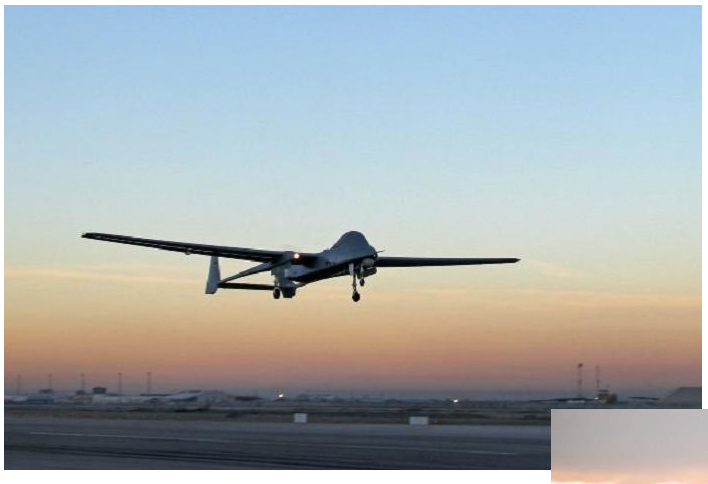
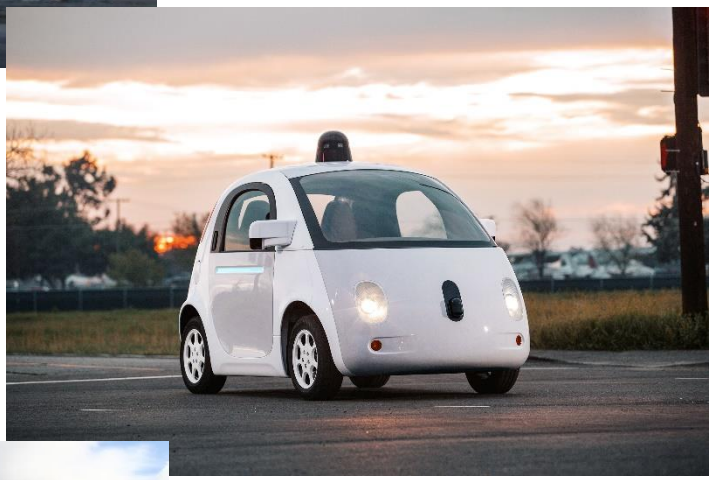
Market Landscape of Unmanned Systems in the Singapore Market 2018





U.S. COMMERCIAL SERVICE
United States of America Department of Commerce

From top to bottom: Heron 1 UAV in flight over Afghanistan (Credit: Bundeswehr/Willke). Google's Gumdrop self-driving car prototype (Credit: Google). C-Enduro 4 USV (Credit: ASV Unmanned Marine Systems)

TABLE OF CONTENTS

Introduction

Singapore is pushing towards becoming the world's first Smart Nation and unmanned systems are a key stepping stone in the pursuit of that goal. In terms of defense, Singapore is updating old UAV technologies meanwhile testing possible future tools on land and in the sea. Singapore spends the most of defense amongst all other ASEAN countries despite being the smallest (USD$10 billion as of 2017[1] with USD$11.2 billion earmarked for 2018[2]). The ministry of defense (MINDEF) overcomes the dearth of eligible military personnel by investing heavily in superior weapons and technology. In fact, MINDEF is one of the largest employers of engineers and scientists in Singapore. The government is also developing similar technologies to serve the public. For example, several agencies are in the early phases of using unmanned vehicles to conduct remote safety inspections as well as assist in firefighting efforts. Even Singapore's commercial sector is beginning to show an interest in widespread adoption of unmanned systems for mail delivery and driverless transportation.

Unmanned air, land and sea systems are still fledgling in Singapore but early research efforts and a commitment to being the most technologically advanced ASEAN nation are strong indicators of massive growth and demand for such technology in the years to come.

In this report, I will highlight some key areas in which Singapore is experimenting with unmanned vehicles to become the world's first smart nation. The report is divided into three sections. Each section will describe the current market landscape for the corresponding technology in terms of competitors, maturity and recent developments. As unmanned vehicles have just recently entered the market space in Singapore, most statistics and data found in other industries are not yet available for Singapore. This uncertainty carries significant risk but firms willing to shoulder that risk could reap the benefits of first market movement. Singapore's optimism and exploration in the field signal a rich market landscape.

[1] http://www.manilatimes.net/aseans-biggest-military-spenders-really/327249/

[2] http://www.straitstimes.com/singapore/transport/commentary-govt-puts-more-money-where-its-mouth-is-when-it-comes-to-buses-and

Aerial Vehicles

Overview

The most prominent of all Singapore's unmanned vehicles is UAVs. Commercial and government sectors are in mid to late stages of development for UAVs but all three branches of the military have been integrating reconnaissance drones for over a decade. UAVs represent a major stepping stone in Singapore's smart nation agenda and the speed of progress being made in military, government and commercial sectors signal strong demand for UAVs and related technologies in the coming years.

Military

The Republic of Singapore Air Force (RSAF) operates a lion's share of UAVs owned by the military, approximately 100 as of 2016[3]. These UAVs span the spectrum of weight classes, functions and developers. RSAF has roughly 40 Searcher II's, 60 Scouts, 2 Heron UAVs. Additionally, the army's brand of UAV is the Skyblade drones meanwhile the navy utilizes ScanEagle UAVs (quantities unknown). This arsenal of non-combative UAVs allows the Singapore Armed Forces (SAF) to exercise extensive and thorough reconnaissance authority on the battlefield.

Suppliers

Israel is the chief supplier of Singapore's UAV needs and the air force's sole supplier of UAVs. Israel Aerospace Industries (IAI) produces the Searcher II's, Scouts and the newest addition to the UAV fleet, the Herons. However, IAI does not maintain the same monopoly on UAVs for the other two branches of the military. The Skyblade III mini-UAV and the Skyblade IV tactical UAV are joint venture projects with efforts from both DSO National Labs and ST Aerospace. The navy's long endurance ScanEagle UAVs are imports from Boeing.

A scan of the current UAV suppliers to SAF indicate that large organizations have a monopoly on the market at this time.

Demand

SAF are forced to combat declining birth rates and an aging population by modernizing their military. This is a theme echoed in all branches of the SAF and a major driving factor for the demand of unmanned systems in the Singaporean military. The defense minister of Singapore has emphasized this point on multiple occasions and the recent addition of Heron UAVs to the fleet support this movement. Heron UAVs are the

[3] http://drones.cnas.org/wp-content/uploads/2016/06/A-Perspective-on-Singapore-Proliferated-Drones.pdf

latest innovation in the unmanned airspace: "It's a significant milestone. The FOC [Full Operational Capacity] of the Heron brings RSAF's (unmanned) aerial capabilities to the level of advanced militaries globally,"[4] says defense minister, Dr. Ng. For comparison, the United States Air Force has the same number for Heron UAVs as RSAF.

MINDEF will continue to replace military personnel with UAVs wherever possible to conserve Singapore's manpower for more specialized duties. Such technologies represent force multipliers for the military. Companies seeking to enter the market should be wary of competing with industry giants to sell whole unmanned systems. Integration of UAVs is still early in Singaporean air space and the SAF purchase history suggests that they buy exclusively from established suppliers or manufacture UAVs in-house. Instead, medium and smaller firms can partner with IAI and Boeing to supply critical components to unmanned systems such as sensor arrays, cameras and other intelligence gathering devices. There is also an opportunity for outside firms to sell such devices to Singapore directly since DSO National Labs has shown interest in building UAVs within country.

The primary purpose of UAVs in SAF are for reconnaissance and target acquisition; non-comparative operations. There are no plans to arm drones although some of the fleet is already capable of weapon attachments. Companies may find success in exporting munitions and air-to-ground missiles to the SAF but MINDEF has not indicated any such intentions publicly. However, it is certainly possible that the government will decide to deploy armed drones in the future if the supply in manpower deteriorates further.

Government

A core component of Singapore's smart nation vision is the use of drones in everything from building inspections to mail delivery. Drone technology will supplant people in dangerous and time-consuming tasks which will complement manpower efforts and augment efficiencies. Mr Ng Lang, Chief Executive Officer of the URA, said, "The current rapid advancement in disruptive technology offers exciting opportunities to explore new ways to plan, develop, and manage the city. Drone technology is one example. It allows us to conveniently capture and generate high-quality, precise 3D digital models of buildings that we used to take weeks to do, and at a lower cost. It is among the range of tools we are experimenting with now that will transform the way we plan for Singapore."

Below is a list of projects which explore the capability and feasibility of drones in the public space:

[4] http://www.straitstimes.com/singapore/rsafs-new-drone-heron-1-now-combat-ready

- The Maritime Port Authority (MPA) of Singapore is working with engineering firm Hope Technik to develop the Water Spider drone to better assess oil spills.[5]
- The Singapore Civil Defense Force announced the use of aerial drones to combat large scale fires by allowing operators to monitor the situation from a birds-eye view and coordinate appropriate countermeasures.[6]
- In 2016, the National Environment Agency (NEA) began testing drones to combat dengue. Singapore's dense urban landscape provides a plentiful breeding ground for mosquitoes and the NEA explored the use of drones to survey breeding areas and deploy larvicide.[7]
- Drones equipped with high resolution cameras are already being used to inspect airplane runways and exterior building facades for structural damage.[8]

Competitors

Various government agencies (including the ones described above) have released tenders and several Singaporean companies have won some of those contracts. Garuda Robotics won a contract in January 2016 to continue development of the Dragonfly quadcopter which is equipped with a camera and payload bay for dispersal of mosquito larvicide[9]. In March 2016, the Dragonfly entered field trials with NEA enforcement officers. Another Singaporean engineering firm, HOPE Technik is collaborating with the MPA to develop and test the Water Spider drone[10]. As for other drone projects, various government agencies call for tenders for private companies to bid on to supply drones and drone equipment. Competitors for these contracts span the global market. Chinese companies are leading the charge for drone production. The link to the contract website can be found in the important links section at the end of this report.

Demand

Most companies bidding on government tenders propose quadcopter vehicles with attachments that vary depending on the objective of the drone. Such vehicles are quiet, energy efficient and nimble enough to traverse Singapore's dense urban landscape. The government is tenacious in its pursuit to become the first smart nation and companies can therefore trust that Singapore is keen on full-scale adoption of drones as soon as possible. However, most, if not all drones winning government tenders are still being tested for feasibility in trials that have been ongoing since 2015. Companies seeking to bid for government contracts should provide effective solutions to tasks which

[5] https://www.mpa.gov.sg/web/portal/home/maritime-companies/research-development/innovation-showcase/projects
[6] http://www.tnp.sg/news/singapore/scdf-fight-fires-sky
[7] http://www.straitstimes.com/singapore/drones-can-check-for-mosquitoes-assist-in-search-and-rescue-efforts
[8] https://www.opengovasia.com/articles/6596-drones-are-a-part-of-singapores-smart-nation-strategy
[9] https://garuda.io/dragonfly/
[10] http://hopetechnik.com/our-business/special-projects/water-spider/

endanger worker safety or are tedious to complete with on-site labor. A key challenge for domestic drones is cyber security. Outside companies will also find success in partnering with hardware firms to provide Singapore's burgeoning drone ecosystem with secure lines of communication.

Commercial

There are several small commercial ventures being pursued in the drone market in Singapore such as drone food servers and air taxis but this section is devoted to unmanned mail delivery. The latter two services operate in niche markets (for Singapore) and currently garner little demand and plenty of skepticism so discussions for those applications will be tabled for this report.

Singapore Post Limited, commonly abbreviated as SingPost[11], began its experimentation with drone delivery in September 2015 when it successfully tested a mail run from mainland Singapore to Pulau Ubin. SingPost claims it was the first UAV point-to-point recipient authenticated mail delivery in the world[12]. This is part of SingPost's strategy to incorporate drone technology as part of a multi-pronged approach to parcel delivery. That strategy entails an "ecosystem of parcel lockers, self-driving cars and drones that are deployed according to their needs," said Dr. Bernard Leong, SingPost's head of Post Office Network and Digital Services.

Economics

At the time of the parcel delivery to Pulau Ubin in 2015, the cost of the single drone with equipment was approximately USD$1150 (the drone in question was an off the shelf model that had been modified by engineers at SingPost). According to Dr. Leong, this hefty price tag will decrease significantly, making drone delivery a feasible application: "Moore's Law is applying to drones and when drone costs go below S$100, and we have a 5G mobile network, the economics will work out, and this could be within the next three to five years," he said.

Two years later, Airbus signed an agreement with SingPost to conduct research and trials on drone delivery[13]. SingPost will focus on logistical infrastructure while Airbus

[11] https://en.wikipedia.org/wiki/Singapore_Post
[12] https://www.channelnewsasia.com/news/singapore/singpost-s-drone-delivery-trials-some-key-takeaways-8599940
[13] http://www.straitstimes.com/singapore/airbus-and-singpost-testing-last-mile-drone-package-delivery

concentrates on engineering and design. The collaboration is expected to begin trials at the National University of Singapore in early 2018.

Land Vehicles

Overview

The market for unmanned land vehicles has its pillars in two key industry sectors. First and foremost is the use of land robotics to assist soldiers on the ground as well as operate independently in dangerous situations. Adoption of these robots in the Singapore Armed Forces (SAF) is not yet widespread but the Ministry of Defense (Mindef) has revealed strong intentions to implement them in the next generation of combat. In the commercial sector, private companies are experimenting with driverless taxi services. Such technologies have the potential to upend established transportation methods used by Grab, Uber and ComfortDelGro.

Military

Last year, the defense minister of Singapore, Ng Eng Hen said, “Modern militaries are powered by technology, and the next-generation SAF, even more so…Our defense technology organizations will gear up to support changes.”[14] However, Singapore has only two unmanned ground vehicles (UGV) made in-country, the Jaeger UGV and MULE UGV. The Jaeger is a multipurpose, all terrain vehicle which can be remotely controlled or operate semi-autonomously. Operators can fit it with telemetry equipment, remote weapons or communications relay as well as many other payloads. On the other hand, the MULE which was a joint venture between ST Kinetics and Lockheed Martin is UGV designed to enter combat situations which is deemed unsafe for a soldier’s presence. With a rising demand for modernization in the SAF and a lack of variety in UGV’s

ST Kinetics Probot, unveiled at the 2018 Singapore Air Show. It utilizes a vehicle developed by Roboteam with a remote-controlled weapon system mounted developed by ST Kinetics. Credit: Straits Times

[14] https://www.channelnewsasia.com/news/singapore/singapore-to-invest-s-45m-a-year-in-new-defence-tech-labs-for-ro-8775120

built in country, an opportunity to import UGV's and associated technologies like sensors and control systems arises. This is exactly what some international defense contractors are already doing. ST Kinetics unveiled the Weaponized Probot at Singapore Air Show 2018. This UGV operates on the remote controlled Probot, manufactured by American firm Roboteam, but it utilizes remote controlled weapons systems developed by ST Kinetics. Current use by the SAF is reserved to field trials and experimentation to observe how well the vehicles can handle missions.

Prospective companies looking to enter the market would should pursue dealings with ST Kinetics and MINDEF to provide communication systems, sensors and remote-controlled weapon capabilities.

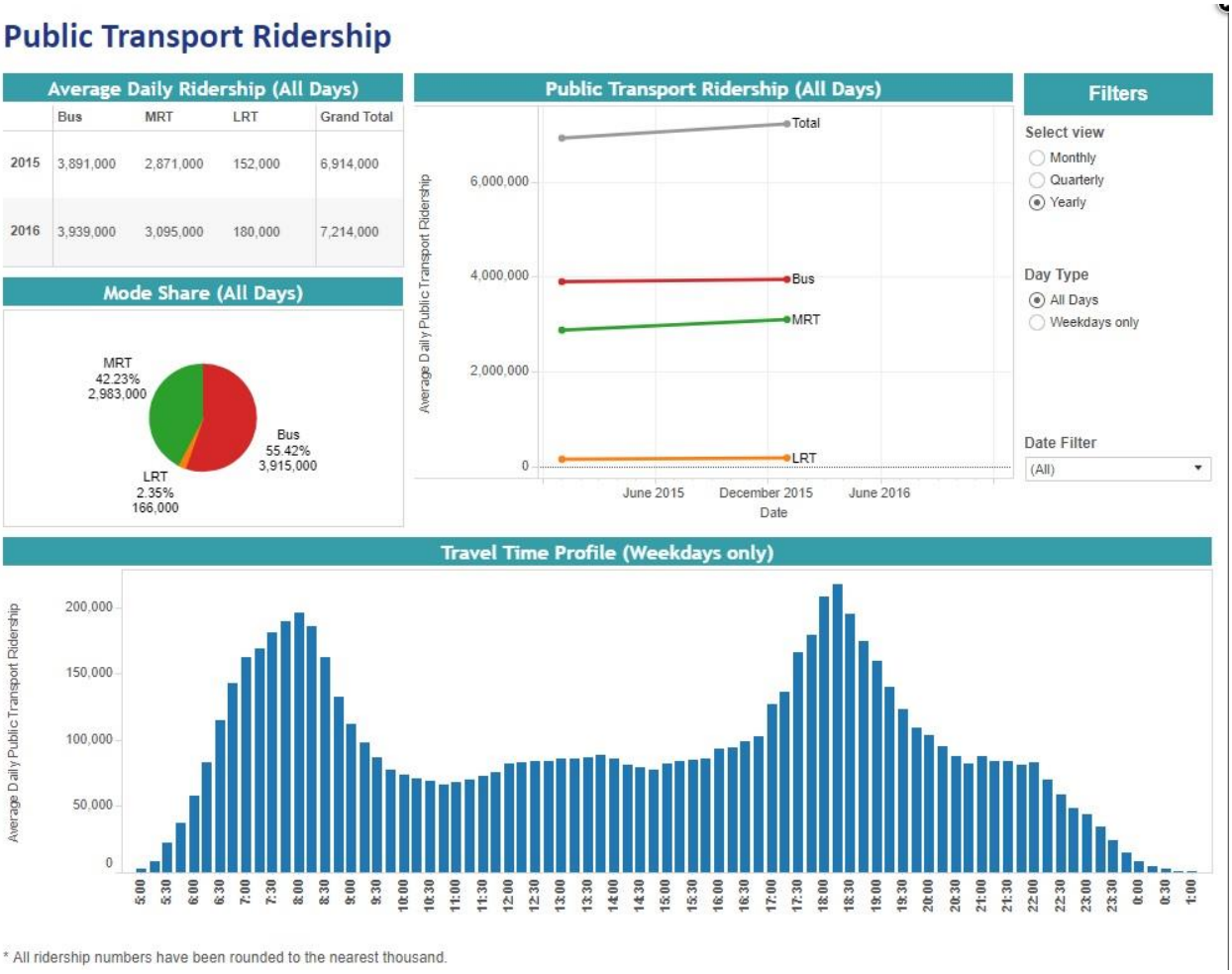
Government

The Singapore Police Force (SPF) debuted its first patrol robot at the 2018 Chingay festival to bolster security efforts. The event was the first trial by the SPF but the organization is developing two other robot prototypes. This patrol robot represents the first of Singapore's efforts to integrate unmanned land vehicles into daily life and there will certainly be more exploration into the field as Singapore develops into a smart nation.

Commercial

Driverless cars are a nascent industry in Singapore, but a few companies have begun conducting road tests at the autonomous vehicle (AV) test centre, constructed last year. The Land Transport Authority (LTA) is meanwhile creating regulations and legislation to facilitate autonomous taxi and bus services rather than widespread personal AV's. Traditionally, Singaporean policy discourages the use of personal vehicles for environmental concerns and land constraints. Starting February 2018, the growth rate of cars and motorcycles on the road will be reduced from 0.25% to 0% per annum.[15] Public transportation, taxis and ride-sharing services will handle the additional stress until 2020 when the growth rate will be revisited. With that being said, current trends in mass rapid transit (MRT) ridership and taxi fleet size indicate that commuters are gradually shifting away from taxis towards public transportation and ride sharing services.

[15] https://www.bloomberg.com/news/articles/2017-10-23/singapore-to-stop-adding-cars-on-its-roads-from-february-2018



Ridership data collected from 2015 and 2016 show the increase of riders on the MRT line to offset large drops in Taxis on the road. Credit: Land Transport Authority of Singapore

Ridership has increased by 300,000 from 2015 to 2016 meanwhile taxi fleet size has decreased by 725 over the same period (and decreased by 5119 from 2015 to 2017[16]). Decreasing taxi fleets and personal vehicles, coupled with increasing public transportation ridership and population size create a perfect environment for autonomous vehicles to decrease commute times, lower taxi fares and relieve stress from MRT lines.

Suppliers

American companies nuTonomy and Delphi are among several companies conducting road testing that began in August 2016. Vice president of engineering for

[16]https://www.lta.gov.sg/content/dam/ltaweb/corp/PublicationsResearch/files/FactsandFigures/taxi_info_2017.pdf

Delphi, Glen DeVos is confident in the demand for the technology, saying, “A cab ride in a dense urban area can cost USD$3 to USD$4 a mile…We think we can get to 90 cents a mile (with an automated vehicle)”[17]. Furthermore, Delphi plans to launch a full-fledged automated cab service by 2022. nuTonomy partnered with Singpapore based ride share service, Grab, in September 2016 and they planned for a commercial launch in 2018. The Singapore Economic Development Board (EDB) has also invested in nuTonomy. Note that Delphi acquired nuTonomy for $450 million on October 24, 2017[18].

Demand

In closing, Singaporean infrastructure and government policy is primed to adopt driverless taxi and bus services to offset increasing demands to public transportation. Such technologies are not yet widespread and available for commercial use but they are in the R&D phase with projections to become commercially available in the early 2020’s. Companies seeking to conduct business in this sector would compete with ride sharing platforms which are already partnering with American AV companies to deploy AV taxi services. The current focus is on software and attachments to convert existing vehicles to perform AV capabilities rather than manufacturing of AV’s from the ground up.

Maritime Vehicles

Overview

Unmanned surface vehicles (USV) discussed in this section concern only the military and government landscape. This is because commercial uses (primarily unmanned cargo ships) are precluded by legal hurdles that have not yet been resolved by Singapore or the global community at large. For more information about the laws surrounding autonomous cargo ships, please see *All Hands Off Deck? The Legal Barriers to Autonomous Shipping* (see useful links at the end of the report).

The use of USVs in Singapore has been dominated by the military to aid maritime engagements and to stave off piracy threats. However, these efforts are young in their adoption but Singapore is ramping up USV demand with two more vehicles completing test trials by the end of 2019. One of these new models is intended for domestic policing and the other is meant to grow RSAFs fleet of USVs.

[17] http://www.straitstimes.com/singapore/transport/delphi-singapore-launch-test-of-self-driving-taxis
[18] https://techcrunch.com/2017/10/24/delphi-buys-nutonomy-for-400-million-to-scale-and-deliver-autonomous-vehicles/

Military

USVs and related equipment should see high demand USV's are currently only being utilized by the Republic of Singapore Navy (RSAF) and the chief engineering companies supplying the navy are ST engineering with the Venus 16 and Rafael Advanced Defense Systems (RAFAEL) with the Protector. The latter has been in use by RSAF since 2005 to combat opposition forces however the Venus 16 is entering the final stages of a year-long trial[19]. RSAF possesses an unpublished number of Protectors for military operations and anti-piracy patrols and currently two Venus 16's. Companies looking to enter this market should expect to compete against large defense contractors such as Lockheed Martin for the supply of USV's. As both the Venus 16 and Protector possess modular design, smaller companies may choose to export remote weapons systems, mine disposal equipment, and a myriad of sensors and sonar. Competitors will include large defense contractors as well as manner smaller firms, especially those from Israel as Israel maintains a very close military relationship with Singapore.

Demand

Demand for USV's in Singapore are constrained to the military and RSAF discloses very little information about their unmanned capabilities. However, Singapore strives to maintain the strongest military in the region but also faces a severe manpower issue. MINDEF's solution to this problem is to harness new technologies such as USV's: "We must harness new technologies, as Dr Teo Ho Pin pointed out, because even if you chose to give us more money in exchange for manpower, we can't do it. We just don't have the manpower, we recognized that as an inherent constraint," Ng Eng Hen, Singapore's Minister of Defense[20]. Using Singapore's rapid adoption of technologies in other sectors, U.S. companies can be assured that RSAF plans to acquire more USV's and related goods as the SAF entrenches itself further as a futuristic fighting force.

Government

The Singapore Police Coast Guard (PCG) is one of the first Singaporean organization to integrate USV technology domestically. Several USVs are undergoing trials started late in 2016 to develop autonomous patrol boats loaded with a bevy of cameras, radars and sensors. No details on the trial end date have been released but, "The Straits Times understands that assessments are currently being made to the USVs' communication systems and the vessels' seaworthiness, including how they react to avoid collisions at sea."[21]. The purpose of these vessels is to detect illegal immigrants

[19] http://www.straitstimes.com/singapore/unmanned-ships-can-find-and-dispose-of-mines-quickly
[20] https://navaltoday.com/2018/03/08/singapore-navy-moves-towards-unmanned-future/
[21] http://www.straitstimes.com/singapore/sea-robots-that-keep-spore-waters-safe

entering the country and to project a greater police presence while easing manpower issues.

A fully autonomous patrol USV undergoing testing, followed by a PCG vessel. Credit: Straits Times

Given Singapore's population and geography, such autonomous patrol boats will be vital to Singapore's "multi-layered" defense. The country's significant military spending and technological adoption are strong indicators that autonomous costal patrols will be in high demand by the PCG in the coming years. U.S. companies seeking to capitalize on the market should focus on selling remote weapons systems as well as cameras and sensors for advanced detection capabilities.

Trade Events

Singapore Air Show
http://www.singaporeairshow.com.sg

Singapore International Robotics Expo
https://www.sire.com.sg/ehome/sire2018/singapore-international-robo-expo

Asia Pacific Maritime
http://www.apmaritime.com/

Last Mile Fulfilment Asia
http://www.lmfasia.com/press-releases

Useful Links

Unmanned Cargo Ships
https://law.nus.edu.sg/cml/pdfs/wps/CML-WPS-1706.pdf

Government Tenders
https://www.gebiz.gov.sg/

UAV Laws
https://www.caas.gov.sg/public-passengers/unmanned-aircraft-systems

References and Key Contacts

Singapore Government Offices:

Singapore Economic Development Board
http://sedb.com

Ministry of Defense
https://www.mindef.gov.sg

Civil Aviation Authority of Singapore
http://www.caas.gov.sg

Defense Science & Technology Agency
http://www.dsta.gov.sg

National Environment Agency
http://www.nea.gov.sg

Marine and Port Authority
https://www.mpa.gov.sg

For More Information

The U.S. Commercial Service in Singapore can be contacted via
Email: Hawcheng.Ng@trade.gov
Phone: (+65) 6476-9037
Fax: (+65) 6476-9080
Website: http://www.buyusa.gov/singapore

The U.S. Commercial Service — Your Global Business Partner

With its network of offices across the United States and in more than 80 countries, the U.S. Commercial Service of the U.S. Department of Commerce utilizes its global presence and international marketing expertise to help U.S. companies sell their products and services worldwide. Locate the U.S. Commercial Service trade specialist in the U.S. nearest you by visiting http://www.export.gov/.