

# Market & Technology Trends

2020 / Edition 1

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European  
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# About GNSS.asia

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Since 2012, GNSS.asia has been bridging GNSS industries from Asia and Europe. Its objective is to facilitate **industrial cooperation** between the two regions, to **support institutional relations and to maximise Galileo adoption**. The project, financed by the **European GNSS Agency**, offers a **series of services to EU industry and institutions**, ranging from **market analyses** and stakeholder mapping, to **business matchmaking**, local marketing opportunities and the latest technology trends!

*Our team members in Japan, South Korea, India, Taiwan and China have an on the ground presence and keep the pulse of local GNSS market developments. In 2018-2019 only, GNSS.asia supported 81 businesses, maintained a network of 28 GNSS institutions in Asia, welcomed over 4000 visitors at its events and facilitated 9 high-level meetings!*

The Asia-Pacific region is home to the highest coverage of GNSS constellations in the world. Its booming economies feature a rapidly growing consumer base and a large potential of GNSS- and space-enabled applications, accompanied by an increasing share of local R&D and technology innovations. Asia is nearly indispensable for companies and SMEs with ambitions to internationalise their GNSS-based product or service.

However, aspiring exporters often face a series of unexpected obstacles. These range from **politicised procurement markets** and market access barriers, to differences in local business cultures, complex market dynamics and an opaque legislative and standardisation framework. Such obstacles are a certain challenge, but easy to navigate with the right knowhow and access to local key stakeholders.

To benefit from our services, **register for industry support** on **[www.gnss.asia](http://www.gnss.asia)**. Our teams are ready to support your GNSS ventures in Asia!



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## List of Acronyms

Acronym	Definition	Acronym	Definition
AEISS	Advanced Earth Imaging Sensor System	MaaS	Mobility as a Service
AGV	Automated Guided Vehicles	MAFF	Ministry of Agriculture, Forestry and Fisheries
AI	Artificial Intelligence	MIC	Ministry of Internal Affairs and Communications
AR	Augmented Reality	MiFID-2	Markets in Financial Instruments Directive - 2
AS	Automated Storage	MitM	Man-in-the-middle-Attack
BDS	BeiDou Navigation Satellite System	MLIT	Ministry of Land, Infrastructure, Transport, and Tourism
BEL	Bharat Electronics Limited	MOLIT	Ministry of Transport
BIM	Building Information Modelling	MOST	Ministry of Science and Technology
BIPM	Bureau International des Poids et Mesures (BIPM)	MOTIE	Ministry of Industry
CARATS	Collaborative Actions for Renovation of Air Traffic Systems	MSAS	MTSAT Satellite-Based Augmentation System
CORS	Continuously Operating Reference Station	MTSAT	Multi-Functional Transport Satellites
FDMA	Fire and Disaster Management Agency	NGII	National Geographic Information Institute
GEMS	Geostationary Environment Monitoring Spectrometer	NICT	National Institute of Information and Communications Technology
GIS	Geographical Information System	NLSC	National Land Surveying and Mapping Centre
GLONASS	GLObal NAVigation Satellite System	NR	New Radio
GNSS	Global Navigation Satellite System	NSA	non-standalone
GNSS-R	Global Navigation Satellite System Reflectometry	NSPO	National Space Organisation
GOCI-II	Geostationary Ocean Colour Imager-2	OBD	Onboard Diagnostic Devices
GPS	Global Positioning System	OPPAV	Optionally Piloted Personal Air Vehicle
GSI	Geospatial Information Authority of Japan	PBV	Purpose Build Vehicles
HEMS	Helicopter Emergency Medical Services	PIPA	Personal Information Protection Act
HSFC	Human Spaceflight Centre	PNT	Positioning, Navigation and Timing
IIT-M	Indian Institute of Technology-Madras	POS	Position and Orientation System
IoT	Internet of Things	PPE	Personal Protective Equipment
ISRO	Indian Space Research Organisation	PTP	Precision Time Protocol (PTP)
ITRI	Industrial Technology Research Institute	QZSS	Quasi-Zenith Satellite System
JAPB	Japan Agricultural Production Bureau	RNP-AR	Required Navigation Performance - Authorisation Required
JASIC	Japan Automobile Standards Internationalization Centre	RS	Retrieval System
JCAB	Japan Civil Aviation Bureau	RTB	Road Transport Bureau
JMA	Japanese Meteorological Agency	RTK	Real-time kinematic
JSDF	Japan Self-Defence Force	SBAS	Satellite-based Augmentation System
KARI	Korea Aerospace Research Institute	SESAR	Single European Sky ATM Research
KISA	Korea Internet & Security Agency	SLAS	Sub-Metre Level Augmentation Service
KOMPSAT	Korea Multi-Purpose Satellite-	SRP	Solution-Ready Package
KPS	Korea Positioning System	TWCC	Taiwan Computing Cloud
KRRI	South Korea's Railroad Research Institute	UAM	Urban Air Mobility
LBS	Location Based Services	UAV	Unmanned Aerial Vehicle
LIDAR	Light Detection and Ranging		

# 1 Key Trends

This GNSS market and technology trends insight report is a comprehensive source of knowledge and information on Asia's diverse GNSS markets. This is the first edition of this new GNSS.asia format, and it aims map upstream and downstream market & technology trends in our focus regions Taiwan, China, South Korea, India, Japan and Australasia.

The below table outlines the areas in which developments have been seen and could form a starting point for a launch into the respective markets, specifically for low-cost receivers compatible with the regional constellations.

Market	Upstream Developments
India	Formation of a new space regulatory organisation to focus on both the space agency and private industry.
China	Finalisation of the BDS-3 constellation, with the last successful launch on 23 June 2020 Planned launch of a new global BeiDou industry innovation centre
Taiwan	Taiwan's long-term national space technology development programme pushing for the development of: <ul style="list-style-type: none"> <li>▪ Six High Resolution Remote Sensing Satellites</li> <li>▪ Two Ultra-High Resolution Remote Sensing Satellites</li> <li>▪ Two Synthetic Aperture Radar Satellites</li> </ul> The NSPO's pushing the development of Taiwan's second domestically developed weather satellite featuring a domestic GNSS-R component
South Korea	The launch of the Korean "Chollian-2B", a GEMS satellite focused on marine and atmospheric data aiming to be fully operational by 2021 Multiple ongoing satellite navigation system programmes in South Korea <ul style="list-style-type: none"> <li>▪ A detailed design for the Korean SBAS (KASS) to be completed in June 2020</li> <li>▪ A preliminary feasibility study of the upcoming local Korea Positioning System – aiming to kick off in 2022 with full operation expected in 2034</li> </ul> Investment in domestic supply chain passed a preliminary feasibility study, with a aim to spend EUR 160 million over the ten years from 2021 Preparations for the first domestically built rocket and two KOMPSATs
Japan	QZSS uptake seen in the B2B professional markets utilising the high accuracy augmentation services including centimetre level accuracy and the Michibiki Unique Services Significant interest in low-cost receivers that are compatible with the QZSS's augmentation signals
Australasia	A high accuracy SBAS system is being developed by Australia and New Zealand, providing an accuracy of ten centimetres by 2023 Australian <i>M-2 Pathfinder</i> launch delayed due to the global pandemic























































Alongside the upstream developments there have been developments in downstream GNSS market segments, streamlined with the categorisation of the European GNSS Agency: Consumer Solutions, Road Transportation and Automation, Manned Aviation, Drones, Emergency Response, Rail, Agriculture, Geomatics, and Critical infrastructure.

	GNSS Market	Trend
	Consumer Solutions	<p>E-Health technologies being utilised all across Asia due to the coronavirus, with telemedicine such as <b>online medical appointments</b> being widely adopted in China and <b>GNSS-based contact tracing apps</b> in South Korea, India, Taiwan, and China.</p> <p><b>QZSS's SLAS</b> is being used in Ashirase – <b>a device intended to replace canes</b> for the visually impaired.</p> <p><b>Investment in the food delivery sector</b> in India.</p>
	Road	<p><b>EUR 830 million investment</b> into a framework for the development of an <b>autonomous driving ecosystem</b></p> <p>Launch of Hyundai's <b>city of the future</b> in South Korea, along with the successful application of <b>GNSS in road vehicles for precision positioning</b> in China and autonomous driving in Taiwan.</p>
	Manned Aviation	<p>Heavy <b>use of air cargo vehicles</b> in China and the development of <b>concept personal air vehicles</b> in South Korea.</p>
	Drones	<p>Several key drone applications seen in Q1 across Asia with uses ranging from <b>delivering hospital supplies</b> in China through to <b>awarding land rights to residents in India</b>.</p> <p><b>Updated drone regulations</b> in Taiwan, Thailand, and South Korea.</p>
	Emergency Response	<p>eCall devices – <b>compatible with the European e-Call</b> - are now compulsory for new vehicle models in Japan since January 2020.</p> <p>GNSS has also been leveraged in the <b>construction of hospitals</b> in the fight against the Coronavirus, in <b>fire monitoring in the Australian fires</b>, and in the creation of an emergency call button in a popular taxi app.</p>
	Rail	<p><b>Real-time train information system</b> introduced in Indian railways using the <b>S-Band Mobile Satellite Service</b> of the ISRO's GSAT6 satellites and GAGAN – a satellite augmentation system.</p> <p><b>Smart high-speed rail</b> deployed in China to reduce commute times.</p> <p>Recent experiments in Japanese <b>identified two major blocking points</b> before GNSS can be widely used in the industry – <b>a fail-safe GNSS system</b> and a <b>procedure to re-acquire GNSS signals after passing through mountains</b>.</p>
	Agriculture	<p>GNSS applications across Asia for <b>smart agriculture</b> in China, <b>rice-planting</b> in South Korea, and <b>crop monitoring</b> in Taiwan.</p>
	Geomatics	<p>Use cases seen this quarter include the <b>e-GNSS RTK positioning system</b> in Taiwan <b>beginning to use Galileo</b>, the mapping of mount Everest using modern techniques in China, and a <b>CORS network being established for use in Indian Surveying</b>.</p>
	Critical Infrastructures	<p>New 5G developments in Taiwan providing a platform for future technological growth including GNSS and AI applications.</p>

In addition to the upstream developments and GNSS market segments, also macro technology trends have a potential (indirect) impact as their application domain often requires location data. Asia is a particularly relevant region in these domains, and is in the driver seat behind several key enabling technologies.

Macro Technology	Trend
Robotics	Robots were used to fight against COVID-19 in Taiwan and Australia. ISRO plans to send one to space as part of their manned space programme.
Big Data	Big Data has been leveraged across Taiwan and China to <b>identify and monitor COVID-19 transmission</b> . <b>Amendments to privacy laws</b> in South Korea and Japan to encourage business applications of big data.
Digitalisation and AI	AI-powered drones have been developed in India to assist in <b>countering rogue drones</b> , along with developments in Taiwan with a <b>public-private AI research and development hub</b> .
Silver Economy	e-Health platforms and applications launched in Taiwan and India.
Sharing Economy	Heavy growth in the Indian rideshare market and <b>a boost in the South Korean car and scooter sharing schemes</b> .

The below table provides a general overview of the potential EU industry opportunities in each segment, based on GNSS.asia's analyses highlighted in this report as well as previous market studies.

Market	Taiwan	China	Korea	India	Japan	Australasia
Consumer Solutions						
Road						
Manned Aviation						
Drones						
Emergency Response						
Rail						
Agriculture						
Geomatics						
Critical Infrastructures						



# 1.1 Our Takeaways

## 1.1.1 Upstream

- Companies in Japan are looking to take advantage of QZSS, but there is a **major barrier to entry** for companies due to the **high price of the receivers**. The uptake of the high accuracy system is being held back by this. This may open opportunities to **European producers of low-cost receivers compatible with the QZSS augmentation signals**.
- The **expansion** of Taiwanese and South Korean **domestic satellite supply chains** is a key target for **partnership opportunities**. European expertise in the construction of satellite components such as GNSS receivers, computing systems, and other related components can be **leveraged to provide support and training for Taiwanese and Korean companies**.
- The **reorganisation of the India space landscape** with both the **new regulatory body In-SPACE** and the **transfer of the operational aspects of the space programme** – satellite operations, rockets, and industry cooperation – **to New Space India LTD** being important to note for any organisation aiming to collaborate with India. This development should **stimulate cooperation with the private sector** – providing an easy avenue for collaboration with the Space Commission and a more open space sector through regulatory rulings.

## 1.1.2 Downstream

- The improvements brought about by the development of the new **Australia-New Zealand SBAS** will provide an entire **new set of downstream applications** across all segments. This provides an opportunity for both countries to benefit from the **introduction of mature European products and services** in segments such as agriculture, and it provides a new marketplace for the European companies specialising in these areas.
- Japan's mandatory **introduction of a vehicle emergency call function** that is **compatible with the European e-Call** opens up the market to companies from Europe. This development has also **created a need for standardisation and certification services – a service area in which European industry excels**.
- **Smart-rail systems** using GNSS are seen in both India and China, with experimental projects and applications in Japan. These advancements could provide an opportunity to European system integrators who have a competitive position on the global market.
- **Drone standards in Thailand** are shifting **towards international standards**. This change will allow businesses in the future to launch drones and drone related components into the market without creating an entirely different product, reducing the barrier to entry. This also works in reverse, with the **increasing regulations meaning that the Thai drone industry will be more suited for entry into**, and cooperation with other markets.



- An example of the influence of national standards can be seen in the **upcoming international adoption of South Korea's** standardisation proposal on '**Low Altitude Drone Communication Protocol**'. This protocol is expected to be established internationally, where it will solve the **problem of each manufacturer using their own communication protocols**. Businesses should look to the current Korean standards and begin their preparations for their adoption in 2022.
- **Taiwan** have also **updated their drone use regulations**, in particular the required inspections as well as the development of UTM-solutions, which will have an impact on any **international companies looking to launch drone-based services in the region**. European industry, which is leading in drone services and drone traffic management, should continue to closely monitor the developments in Thailand, South Korea and Taiwan.
- South Korea have made changes to their '**Passenger Transport Service Act**' which **has added additional barriers to enter the ride-hailing market**, and effectively banned the use of Tada, a domestic van-hailing market. The changes **prohibit the operation of rental services if the driver does not have a tax licence**.
- The increase in **healthcare related applications** suggests that there is an opportunity for cooperation between the European and Asian markets. Partnerships in this area **would allow for the recent developments in Asia to be brought to the European markets**.

## 2 India

### 2.1 Introduction

India has emerged as **the fastest-growing major economy** with an estimated GDP growth of 12 percent in 2019-20 and it is the **third-largest start-up hub in the world**, being home to over 9,000 start-ups. India's huge population, when combined with the rapid growth of smartphones and internet accessibility showcase the vast potential the country has for GNSS applications.

Segment		Key Trends
<b>Upstream</b>		Formation of a <b>new space regulatory organisation</b> to focus on both the space agency and private industry.
<b>Market Trends</b>	Consumer Solutions	Jio <b>Launched Connected Car Technology</b> at the 15th Auto Expo Swiggy, <b>India's Largest Food Delivery Company Raises \$113M</b> in Series I Funding
	Road Transportation & Automotive	Indian <b>GPS-Based Fleet Management Company Raise EUR 2.5 Million</b> in Series I Funding
	Drones	Drones and GIS used to <b>Award Land Rights to Odisha Slum Residents</b>
	Emergency Response	Cooperation Between the <b>Ola Cab app</b> and the <b>Bangalore Emergency Services</b>
	Rail	<b>Real-Time Train Information System</b> Deployed on Indian Railways
	Agriculture	Noida <b>Start-Up Helped 20 Million Farmers</b> Using Location and Weather Data
	Geomatics	CORS Used to <b>Augment GNSS Networks for Indian Survey</b>
<b>Macro Technology Trends</b>	Robotics	ISRO announcing their plans in January to <b>send 'Vyomamitra' -a lady robot</b> – in the first stages of their manned space programme
	Big Data	Indian data analytics company SpoonShot is combining AI with big data to <b>deliver personalised food market insights</b>
	Digitalisation and AI	Indian Institute of Technology-Madras (IIT-M) has developed an <b>AI-powered drone that can counter rogue drones.</b>
	Silver Economy	Arvi Healthcare Management <b>Platform Launched for Senior Citizens</b>
	Sharing Economy	QuickRide carpooling hit a milestone <b>of 3.9 million users</b> across India after having a <b>record 4x growth in 2019</b>
	Other	Apps developed to curb COVID 19 and to assist people with their <b>health management.</b>

## 2.2 Upstream Developments

### 2.2.1 New Indian Space Regulator 'In-SPACE'

New developments in India this year with the development of a new Indian regulatory body and a reorganisation of the **Indian Space Research Organisation (ISRO)**. The **Indian National Space Program and Authorisation Centre (In-SPACE)** is a newly formed regulatory body for both the space agency and private firms. Alongside this, ISRO will be focused primarily on new technologies, human spaceflight, and deep space missions, with **New Space India LTD** being the commercial arm which is taking over the **operational aspects including satellites, rockets, and engagement with industry for new applications and infrastructure**.<sup>1</sup>

## 2.3 GNSS Market Trends

### 2.3.1 Consumer Solutions

The continued growth of smart mobile devices, wearables, internet accessibility, and cloud computing provide a platform for consumer solutions delivered by location based solutions in India.

#### 2.3.1.1 Jio Launched Connected Car Technology at the 15<sup>th</sup> Edition Auto Expo

**Reliance Jio Infocomm** is rolling out their scalable connected car technology by the end of the year.<sup>2</sup> This technology involves **embedded eSIM's** which makes the **cars act as smartphones** and is to be **combined with additional sensors and LIDAR technology** in order to allow real-time analytics, telematics for predictive maintenance, route planning, and road safety.

Jio already have the Jio Car Connect – a **combination of hardware devices and mobile apps aiming to connect 90% of the cars on the road in 2020**. This solution is powered by the onboard diagnostic devices (OBD) and will **combine precision location data with geo-fencing** to locate the vehicle after a theft or accident.

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<sup>1</sup> <https://economictimes.indiatimes.com/news/science/in-space-will-be-the-new-space-regulator-navigation-bill-on-cards-k-sivan/articleshow/76618755.cms?from=mdr>

<sup>2</sup> <https://analyticsindiamag.com/reliance-jio-to-finally-launch-a-scalable-connected-car-solution-which-it-has-promised-for-years/>

### 2.3.1.2 Swiggy, India's Largest Food Delivery Company Raises \$113M in Series I Funding

India's largest food ordering and delivery platform **Swiggy has raised \$113 million** (EUR 100 million) in their series I funding round.<sup>3</sup> Swiggy has over 160,000 restaurant partners and is growing by 10,000 every month. Their delivery services relies on the **precise location data** of the delivery partners **provided by GNSS**, cell phone networks, and **other location based technologies to track and monitor their deliveries**.

## 2.3.2 Road Transportation and Automotive

### 2.3.2.1 Indian GNSS-Based Fleet Management Company Raise EUR 2.5 Million

**India has one of the largest road networks in the world**, with over 64% of goods being transported by roads, and 90% of passengers using the network provide a huge market for location based technologies.<sup>4</sup> This market is **ripe for investment** as seen by the **EUR 2.5 million in funding raised by FleetX** in their series A investment round.<sup>5</sup> FleetX is aiming to revolutionise this market with their **fleet management and predictive analytics software by combining GNSS data** with their artificial intelligence, machine learning, and sensors to help **improve the efficiency, safety, and cost-effectiveness** of fleets of vehicles.

## 2.3.3 Drones

The drone industry is currently experiencing a boom with the increase in commercial applications, with **drones being able to simplify complex tasks and work in extreme conditions**. The **Indian unmanned aerial vehicle (UAV) market is expected to reach \$885.7 million (EUR 786 million) by 2021**, with the global UAV market size approaching \$21.47 billion (EUR 19.07 billion).<sup>6</sup> **India's drone industry is experiencing rapid growth**, with a predicted compound annual growth rate of 18% during 2017-23.

### 2.3.3.1 Drones and GIS used to Award Land Rights to Odisha Slum Residents

**Odisha, India has one of the highest urbanisation rates** with a growth rate of the 26.8% in last decade as people relocate to the urban areas in search of a better livelihood. This growth rate **results in temporary settlements with little to no formal documentation on the residents**. This lack of document creates **roadblocks for residents in terms of access to finance and insufficient government service** being provided in the area.

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<sup>3</sup> <https://www.pymnts.com/news/investment-tracker/2020/swiggy-gets-113m-in-funding-round/>

<sup>4</sup> <https://www.ibef.org/industry/roads-india.aspx>

<sup>5</sup> <https://entrackr.com/2020/02/fleetx-raises-rs-10-cr-in-series-a-round/>

<sup>6</sup> [https://www.ey.com/Publication/vwLUAssets/ey-make-in-india-for-unmanned-aircraft-systems/\\$File/ey-make-in-india-for-unmanned-aircraft-systems.pdf](https://www.ey.com/Publication/vwLUAssets/ey-make-in-india-for-unmanned-aircraft-systems/$File/ey-make-in-india-for-unmanned-aircraft-systems.pdf)

The Government of Odisha have been utilising drones to obtain images and location based data of the area in order to solve this.<sup>7</sup> The images captured by drones are being used to create GIS databases which are being used to promote community cooperation using smart devices and apps. The use of drones to map the area resulted in a **90% reduction in implementation time** for the project, which so far has **provided 70,000 certificates of residence**.

## 2.3.4 Emergency Response

### 2.3.4.1 Cooperation Between the Ola Cab app and the Bangalore Emergency Services

To ensure customer safety **taxi company Ola has partnered with Bangalore police**, integrating an emergency button into the car hailing app.<sup>8</sup> With this feature, users can directly call Bangalore police, with the **app automatically providing the police with real-time access to the customer's** information such as name, address, emergency contact details, and location, allowing the police to respond to emergency situations immediately.

## 2.3.5 Rail

### 2.3.5.1 Real-Time Train Information System Deployed on Indian Railways

**Indian railways have deployed real-time train information system (RTIS)** in all of their locomotives.<sup>9</sup> The RTIS is commissioned through the Central Railway Information System (CRIS), the information technology arm of Indian Railways that is under the technical guidance of the Space Application Centre at ISRO. This system **provides real-time positional information of locomotives to facilitate the automatic acquisition of train movement data**, including that of departure, arrival, and the run through timings at the railway stations en-route. The **RTIS optimises traffic management and improves operational efficiency and pre-empt accidents**.

The **GAGAN (a satellite augmentation system for the Indian Airspace)** based device has been developed by Bharat Electronics Limited (BEL). The device which tracks the location of the train using **S-Band Mobile Satellite Service of ISRO's GSAT 6 satellite as well as 4G mobile data**.

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<sup>7</sup> <https://analyticsindiamag.com/case-study-how-the-government-of-odisha-used-geospatial-technology-to-provide-land-rights-to-slums/>

<sup>8</sup> <https://inc42.com/buzz/olas-emergency-button-now-linked-to-bengaluru-police-app/>

<sup>9</sup> <https://economictimes.indiatimes.com/industry/transportation/railways/bharat-electronics-commissions-real-time-train-information-system-for-indian-railways/articleshow/73433674.cms>

## 2.3.6 Agriculture

The **agriculture sector is responsible for the employment of 50% of the country** and is responsible for 18% of India's GDP. Despite this, the sector constantly struggles with the unpredictable and irregular weather conditions, and it has caused an unprecedented loss of produce and capital. Accurate weather predictions would allow this to be mitigated and show great potential.

### 2.3.6.1 Noida Start-Up Helped 20 Million Farmers Using Location and Weather Data

The **Noida based start-up Skymet** has come forward to solve the challenge and installed over **7,000 automated weather stations to generate real-time weather and crop monitoring data**.<sup>10</sup> With real-time weather and location advice, a **farmer can make time-sensitive decisions regarding crops, irrigation methods and pesticides**. Skymet also provides services in crop surveillance and monitoring, risk mitigation in banking and in agriculture insurance.

## 2.3.7 Geomatics

### 2.3.7.1 CORS Used to Augment GNSS Networks for Indian Survey

Surveying land using GNSS technologies is limited due to the **limited accuracy of GNSS signals**. The Survey of India has leveraged **continuous operating reference stations (CORS) to augment the GNSS data**, this augmentation improves the accuracy and allows measurements to be accomplished in minutes.<sup>11</sup> CORS takes the overall productivity to the next level by **overcoming the limitations of the current RTK technique**. The system will **augment the NAVIC network along with other GNSS networks** including GPS, Galileo, and GLONASS.

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<sup>10</sup> <https://yourstory.com/socialstory/2019/12/skymet-spacetechn-startup-agriculture-weather-application>

<sup>11</sup> <https://www.geospatialworld.net/blogs/survey-of-india-to-establish-nationwide-cors-network/>

## 2.4 Macro Technology Trends

India have several government initiatives such as *Digital India* and *Make In India* that have increased the adoption of cutting edge technology such as Artificial Intelligence, Machine Learning, and Cyber Security which are **changing the very way that business is conducted and are creating new markets throughout India.**

### 2.4.1 Robotics

There has been a rapid increase in the utilisation of robots throughout several industries, with the **largest adopter of robotic solutions being the automotive sector**. The coronavirus pandemic has speed up the adoption of **robotics in other sectors such as food delivery and in the healthcare industry**, with plans being to utilise robots to serve COVID-19 patients.

The rise in **robotics even extends to the space industry**, with the ISRO announcing their plans in January to send '*Vyomamitra*' -a lady robot – in the first stages of their manned space program.<sup>12</sup> This **robot is intended to simulate human functions in space**, and to interact with the environmental control life support system.

### 2.4.2 Big Data

A recent trend in the market is the **rapid shift towards digital transformations**, with big data becoming one of the most prevalent technologies. **India is one of the leading producers of big data**, just after the United States and China.

The **Indian data analytics company SpoonShot** is combining AI with big data to deliver **personalised insights and trends for the consumer packaged goods industry**.<sup>13</sup> This allows consumers to make quick, data-driven decisions.

### 2.4.3 Digitalisation and AI

The Indian Institute of Technology-Madras (IIT-M) has developed an **AI-enabled drone that will be used to counter malicious drones**. This system is designed to help secure air space – **ideal for law enforcement, security firms, and for use in airports.**

The drone is designed to **transmit false GNSS signals** at a much higher power than traditional satellites in order to confuse the rogue drone. The AI-enabled drone generates **fake GNSS packets** with a **manipulated time difference** to trick the drone, allowing the user **to alter the position and time of the malicious drones in order to disable it.**

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<sup>12</sup> <https://www.businessinsider.in/science/space/news/isros-humanoid-lady-robot-will-fly-into-space-before-they-send-astronauts-out-on-gaganyaan/articleshow/73519075.cms>

<sup>13</sup> <https://www.americaninno.com/minne/twin-cities-startup/how-spoonshot-uses-ai-to-predict-the-future-of-food/>



This spoofing technology has been **tested against most major civilian GNSS receivers** currently used in the unmanned aerial vehicle industry and **has been found be able to successfully take down drones within a few seconds**.<sup>14</sup>

## 2.4.4 Silver Economy

### 2.4.4.1 Arvi Healthcare Management Platform Launches for Senior Citizens:

Arvi, a **healthcare management platform recently launched an emergency response app**.<sup>15</sup> This app allows the senior citizen has to press the **button on their mobile screen to launch an automatic alert** which is then sent to family members whilst the Arvi support team **track the location of the mobile via GPS** and organises urgent medical support. This app aims to help senior citizens to track, monitor, and improve their health outcomes.

## 2.4.5 Sharing Economy

The sharing economy in India is **expected to reach USD 2 billion (EUR 1.78 billion) industry by the end of the 2020**, providing solutions in mobility, workspaces, and even co-living house-share solutions.

One of the **key solutions in this sector is ride-sharing**, with QuickRide – one of the most prominent carpooling services in India – **hit a milestone of 3.9 million users** across India after **having a record 4x growth in 2019**.<sup>16,17</sup> QuickRide combines **location data, AI and data analytics** in order to optimise resources, detect fraud, and to improve the overall customer experience.

## 2.4.6 Other

The Government of India has **launched the Aarogya Setu app**, a tracking app that **combines location data with the users Bluetooth data** in order to let users know if they have potentially been in contact with someone who has tested positive for the coronavirus.<sup>18</sup> The app supports eleven languages and **has already achieved 100 million downloads**.<sup>19</sup>

Alongside the Aarogya Setu app, there are **several mobile apps** developed by both central and state governments and private enterprises to **curb COVID 19 and to assist people with their health management**.

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<sup>14</sup> <https://cio.economictimes.indiatimes.com/news/next-gen-technologies/iit-m-develops-ai-powered-drone-to-tackle-rogue-drones/74493679>

<sup>15</sup> <https://economictimes.indiatimes.com/small-biz/startups/newsbuzz/senior-citizen-healthcare-startup-arvi-launches-its-app-in-india/articleshow/74453679.cms?from=mdr>

<sup>16</sup> <https://economictimes.indiatimes.com/small-biz/startups/newsbuzz/cheaper-than-ola-uber-how-quick-ride-is-making-office-commutes-convenient/articleshow/74127971.cms>

<sup>17</sup> <https://www.outlookindia.com/newscroll/carpools-facilitated-by-quick-ride-witnesses-a-4x-growth-in-2019/1694470>

<sup>18</sup> <https://gadgets.ndtv.com/apps/news/aarogya-setu-app-75-million-downloads-mark-amid-coronavirus-outbreak-privacy-concerns-2219241>

<sup>19</sup> <https://entrackr.com/2020/05/aarogya-setu-crosses-100-mn-download-mark/>

## 3 China

### 3.1 Introduction

China was the first country in the world to be affected by the COVID-19 pandemic, **and the first to apply satellite navigation technology to mitigate its impact**. In March, China has gradually started to recover from the COVID-19 outbreak. The Chinese government is promoting business resumption to bring back and unleash consumption potential that had been temporarily held up by the COVID-19 outbreak. Alongside resuming existing projects, **China is eyeing "new infrastructure" projects to offset the economic impact of the COVID-19** and boost economic growth.

The construction of new infrastructure including 5G networks and data centres will be accelerated. In terms of satellites, China has **launched a new satellite of the BeiDou Navigation Satellite System (BDS)**, with only one step remaining before the BDS system is completed.<sup>20</sup> As of the first quarter of 2020, all of the first generation BDS-1 satellites are no longer operational, being replaced by the **54 BDS-2 and BDS-3 satellites** that have been launched. China's navigation satellite fleet has now been completed after its last mission on 23 June. In addition to the success, there has also been a launch failure early 2020: China's first new-generation Long March 7A rocket **failed to enter geosynchronous transfer orbit**.<sup>21</sup>

To capitalise on the launch of BDS, the Beijing municipal government **has released a three-year plan to promote the innovation and development of industries** related to BeiDou PNT-solutions.

Segment		Key Trends
Upstream		Launch of a <b>new BDS-satellite</b> with the last launch planned anytime soon
Market Trends	Consumer Solutions	<b>Telemedicine</b> and Tele-health used to combat the coronavirus
	Road Transportation and Automotive	GNSS <b>Enabled Public Transport Buses</b> Rolled Out
	Manned Aviation	<b>Air cargo</b> as an important force in <b>national emergency relief</b>
	Drones	GNSS-driven autonomous drones for <b>hospital supplies and quarantine enforcement</b>
	Emergency Response	Emergency Field Hospitals Constructed with the help of GNSS Drones used to <b>deliver medical resources</b> to fight COVID-19 GNSS Road Vehicles used in the Fight Against the Pandemic

<sup>20</sup> [http://www.xinhuanet.com/english/2020-03/09/c\\_138859838.htm](http://www.xinhuanet.com/english/2020-03/09/c_138859838.htm)

<sup>21</sup> <https://spacenews.com/launch-of-chinas-new-long-march-7a-ends-in-failure/>

Segment		Key Trends
Market Trends	Rail	Beijing-Zhangjiakou <b>Smart High-Speed Rail Reduces Commute Time by 70%+</b>
	Agriculture	<b>Autonomous Vehicles</b> Used in Smart Agriculture around the Country
	Geomatics	Everest 2020 Altimetry Team <b>Utilise Modern GNSS Geodetic Techniques</b> Chinese Ministry of Natural Resources launches SkyMap 2020 Guizhou Achieved Three New 'Firsts' in Remote Sensing Imaging
Macro Technology	Robotics	<b>Multiple Smart Taxi Companies</b> Begin Development and/or Launch
	Big Data	Big data combined with location data to <b>identify people who have been in close contact with confirmed cases of COVID-19</b>

## 3.2 Upstream Developments

According to Beijing's 'Implementation Plan for Promoting BeiDou Technology Innovation and Industrial Development (2020-2022)', BeiDou will be "deeply applied" in seven major fields such as **smart Winter Olympics**, environmental protection, and **smart transportation** which will create a **benchmark for smart cities in China**. The plan proposes to build a high-precision signal service network, based on core technologies such as Geographic Information Systems (GIS) and Building Information Modelling (BIM) which will be integrated with Beijing's 5G planning layout. The high-precision signal service network will **ensure that the city's outdoor real-time precise positioning accuracy is better than 1 meter and that the accuracy in key areas is better than 5 centimetres**.<sup>22</sup>

Apart from this, several other BeiDou+ demonstration projects are underway:

1. By **combining BDS technology with big data**, the BeiDou+ Urban Lifeline Support Demonstration Project will achieve: basic information acquisition, dynamic updates of water, electricity, gas, heat and other municipal pipelines, intelligent inspection, and emergency rescue and disaster early warning.
2. To promote **high-precision applications** for public vehicles in order to utilise the BeiDou high-precision location service technology in areas such as **urban traffic management (UTM)**, garbage collection, transportation, and processing, refined city management, and other high precision applications. This is combined with the promotion of BeiDou **high-precision time synchronization technology** in the city's rail transportation operation and management.

<sup>22</sup> [http://www.beijing.gov.cn/zhengce/zhengcefagui/202002/t20200224\\_1667898.html](http://www.beijing.gov.cn/zhengce/zhengcefagui/202002/t20200224_1667898.html)

3. The BeiDou+ Urban Safe Operation Demonstration Project will build a **city information model network data platform** for bridges, tunnels, large and important buildings, and other urban infrastructure in Beijing.
4. The BeiDou+ Urban Ecological Environmental Protection Demonstration Project will build a **satellite application service platform** for the Beijing-Tianjin-Hebei region to conduct **PM2.5 monitoring** and collect **meteorological information**. This project will be used for the Beijing 2022 Winter Olympics, where digital maps and **VR panoramas of Winter Olympics venues** will be constructed.
5. BeiDou's **high-precision indoor and outdoor signal broadcast service network** provides seamless positioning, which is being utilised to improve the city's real-time bus and rail traffic data to provide users with **door-to-door integrated intelligent travel services** covering the city's bus, subway, driving, cycling, and hybrid travel modes to create an intelligent public service. **High precision indoor maps of key public areas** that have **high pedestrian flow** provide indoor and outdoor navigation using smartphones, this is applied in areas such as shopping malls, sports stadiums, and transportation hubs.
6. **BeiDou positioning and status monitoring** will be installed on qualified **logistics drones, distribution robots, unmanned distribution vehicles**, and other equipment, this data is combined with sensors that monitor the inertia, visions, and power, along with the **monitoring of the position and operational status in real-time** and will be used to ensure the correct, efficient, and controlled operation of distribution tasks. This monitoring system will also be **promoted for cold-chain logistics and transportation vehicles**, combining the application of temperature sensors, magnetic door sensors, and video surveillance to realise real-time monitoring of the transportation status to **improve the level of food safety and security** for cold storage and refrigeration.
7. The **high-precision location service** network deployed around the Winter Olympic venues is combined with the previously mentioned digitalised maps and VR panoramas to achieve **real-time indoor navigation and positioning of event personnel**. The establishment of the **smart information systems** in the Olympic competition areas is a demonstration of the possible **applications of BeiDou for the construction and management of venues**, storage and transportation of materials, operation of competition venues, and event service, and the success of the application will **setup a baseline for sustainable smart city development** in the region after the competition.

Moreover, the plan proposes to create two special BeiDou bases: a **BeiDou Industrial Innovation Base** in Yizhuang and a **BeiDou Application Demonstration Base** in Shunyi. By 2022, the total output value of Beijing BeiDou navigation and location services industry should **exceed 100 billion CNY (12.8 billion EUR)** along with the launch of a new **global BeiDou industry innovation centre**.<sup>23</sup>

<sup>23</sup> [http://www.beijing.gov.cn/zhengce/zhengcefagui/202002/t20200224\\_1667898.html](http://www.beijing.gov.cn/zhengce/zhengcefagui/202002/t20200224_1667898.html)

## 3.3 GNSS Market Trends

### 3.3.1 Consumer Solutions

During the **COVID-19 pandemic**, the Internet became irreplaceable as it was the only channel that guaranteed China's connection to the outside world. The internet was vital in providing daily travel advice and news information, with many organisations publishing the latest pandemic-related news online. In the early stages of the pandemic there were very limited medical resources available resulting in a **rise in the number of online consumer medical solutions**.

#### 3.3.1.1 Telemedicine Used to Combat COVID-19

**Chinese telemedicine services** such as Ali Health (part of Alibaba), JD Health, and WeDoctor (backed by Tencent) **quickly launched online coronavirus clinics to triage and treat patients** across the country.<sup>24,25</sup> JD Health is now conducting about **2 million online consultations per month**, up tenfold since the outbreak. These **new telehealth platforms** have enabled patients in China to access care without having to travel, thereby **reducing the risks of exposure and spread**.<sup>26</sup> West China Hospital of Sichuan University partnered with ZTE and China Telecom to **rapidly deploy indoor and outdoor 5G networks to connect doctors with patients remotely**, thereby reducing providers' risk of exposure and making it possible to treat more patients across disparate locations without having to travel.

### 3.3.2 Road Transportation and Automotive

There are other applications of the BeiDou Satellite System throughout China, such as the **utilisation of BDS in tracking the precise location of public transport** to allow for real-time dynamic supervision of buses throughout the city.<sup>27</sup> BeiDou is being applied as an 'eye in the sky' **monitoring system to detect illegal use of public transport**. The **BeiDou system has already been successful in the monitoring of the public buses** in areas including Fujian, Guangdong, Yunnan, Anhui, and Shaanxi. Some examples of the applications include:

- The Jiangsu Jiangyin Commission for Discipline Inspection has encouraged the use of **BeiDou positioning systems to issue warnings to the bus automatically if it crosses specific geofences**. There is geofencing applied around tourist attractions and entertainment venues amongst other locations.

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<sup>24</sup> <https://www.economist.com/business/2020/03/05/millions-of-chinese-cooped-up-and-anxious-turn-to-online-doctors>

<sup>25</sup> <https://www.ajmc.com/journals/issue/2020/2020-vol26-n4/incorporating-telemedicine-as-part-of-covid19-outbreak-response-systems>

<sup>26</sup> <https://pandaily.com/ep-64-telemedicine-in-china-in-the-time-of-covid-19-part-2/>

<sup>27</sup> <http://www.elecfans.com/d/759715.html>

- In the Zhejiang Wenzhou Longwan District, if the bus is found to be **driving outside of working hours it will automatically be reported** to the District Commission for Discipline Inspection.
- Other areas are exploring the **combination of GNSS data with Big Data technology** to analyse the bus routes and find data clues that indicate that there has been private use of the buses.

Any locations that are not part of the uniform schemes are being encouraged to start their own pilot schemes.

### 3.3.3 Manned Aviation

Air cargo has been an important force in national emergency relief.<sup>28</sup> In the wake of the pandemic, the **demand for emergency medical supplies has risen sharply**, several air transport enterprises have opened up green channels for the **transportation and distribution of pandemic prevention materials**. These enterprises include Eastern Airlines, Post, Shunfeng, Yuan Tong, Jinpeng and other cargo airlines who are **flying domestic and foreign cargo charter flights to transport the emergency relief materials to Wuhan**. The table below shows the number of flights to Wuhan by each airliner between 25 January and 6 March.

Airline	Number of Domestic Support Flights
Shunfeng Airlines	159
Eastern Airlines	82
Southern Airlines	66
China Post Airlines	57
Air China	20
Xiamen Airlines	14
China Summer Airlines	12
Changlong Airline	11

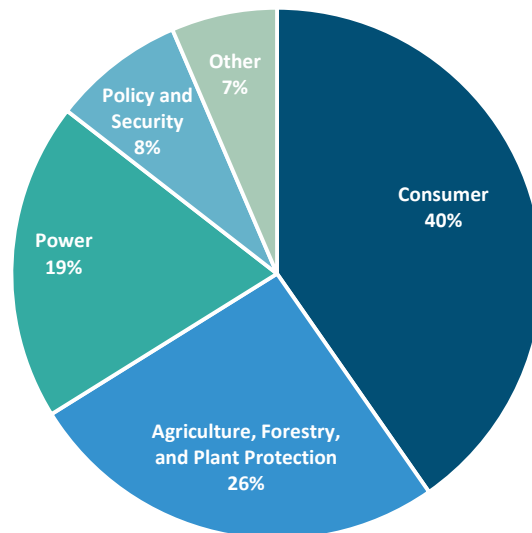
As of 23 March, the civil aviation system has **guaranteed a total of 30,333 flights** involving pandemic prevention and control, transporting 414,951 pieces of prevention and control materials, weighing a total of 386,854 tones. Of these flights, **747 were to the Hubei province** carrying 107,071 pieces of prevention and control materials for a total of 10,347 tons. A further **391 were transporting foreign aid materials**, carrying a total of 155,929 pieces of prevention and control materials weighing 1,494 tons. This would not have been possible without a central coordination and decision making system making use of location based technologies such as GNSS.

<sup>28</sup> <http://news.carnoc.com/list/528/528067.html>

### 3.3.4 Drones

At the 10th Drone Conference in 2019, Wei Zheng, Deputy Secretary General of the China Remote Sensing Applications Association, announced that **285,000 drones have been registered in China's civilian drone market** with a breakdown of the types of drones being seen in the chart below.

**Drone Market Shares in China**



The 2019 China Drone Industry Market Outlook Research Report predicts that the **global drone market size will reach \$70 billion (EUR 65 billion) by 2025**, while China's industrial-grade drone market will reach \$40 billion (EUR 37 billion), with about \$20 billion (EUR 17.8 billion) in agriculture, forestry and plant protection, \$15 billion in security (EUR 13.3 billion), and \$5 billion (EUR 4.6 billion) in power inspection. However, this is based on data from 2019 and it does not account for the rapid increase in drone applications due to the lockdown.

During the pandemic, drones were used in **large-scale disinfection using BeiDou's high precision positioning service to accurately disinfect areas, delivery of medical resources and quarantine materials**, as well as **daily belongings to the high-risk areas to avoid unnecessary infections by human contact**.<sup>29,30,31</sup> Other than that, applications also exist in **border control and epidemic prevention and control**, in **smart agriculture or 'drone planting'** as well as **forestry disease control**.<sup>32,33,34</sup>

<sup>29</sup> <https://spacewatch.global/2020/03/spacewatch-gl-op-ed-how-space-technologies-help-fight-the-coronavirus-in-china/>

<sup>30</sup> <https://www.gpsworld.com/china-fights-coronavirus-with-delivery-drones/>

<sup>31</sup> <https://www.iyiou.com/p/123753.html>

<sup>32</sup> <https://society.yunnan.cn/system/2020/05/06/030665417.shtml>

<sup>33</sup> <http://www.geekpark.net/news/255962>

<sup>34</sup> <https://www.thehour.cn/news/330798.html>



### 3.3.5 Emergency Response

#### 3.3.5.1 Emergency Field Hospitals Constructed with the Help of GNSS

High-precision devices were essential in the **setup of the emergency field hospitals** in Hubei, with the devices enabling the **record breaking construction time** of 2,600+ beds within 10 days.

#### 3.3.5.2 Drones Used to Deliver Medical Resources to Fight COVID-19

Hundreds of **drones have been used for the distribution of medical resources** and pandemic prevention resources to medical staff in the fight against COVID-19. BDS-based robots of the e-commerce and logistics company **JD.com successfully delivered medical materials to hospital in isolation areas.**<sup>35</sup>

#### 3.3.5.3 GNSS Road Vehicles in the Fight Against the Pandemic

**GNSS enabled road vehicles** have been utilised in the fight against the pandemic, with over **6 million vehicles having received pandemic prevention and transportation service information** from the BeiDou satellites. China Post Group Co., Ltd. have also installed 5,000 BDS terminals in their trucks, and they have used the **real-time positional data to ensure the timely delivery of PPE.**

### 3.3.6 Rail

#### 3.3.6.1 Beijing-Zhangjiakou Smart High-Speed Rail Reduces Commute Time by 70%+

Before *Beijing's Implementation Plan for Promoting BeiDou Technology Innovation and Industrial Development (2020-2022)* saw the completion of **Beijing-Zhangjiakou smart high-speed rail line into operations, reducing the commute time from 3 hours to only 50 minutes.**<sup>36</sup>

Agriculture.

#### 3.3.6.2 Autonomous Vehicles Used in Smart Agriculture around the Country

**Unicore and XAG XMission cooperation** demonstrated their drone applications in smart agriculture with centimetre-level navigation accuracy.<sup>37</sup> As a pilot player in drone industry, XAG cooperated with **Bayer in crop digital farming.**<sup>38</sup> Unistrong, a strong local player in the GNSS field has introduced **self-driving tractors all across China** using the BDS constellation.<sup>39</sup>

<sup>35</sup> <https://jdcorporateblog.com/jds-robot-delivers-first-order-in-wuhan-in-coronavirus-aid-support/>

<sup>36</sup> <https://v.qq.com/x/page/x3044v4pvrz.html?>

<sup>37</sup> <https://www.gpsworld.com/unicore-gnss-guides-xag-drones-in-china/>

<sup>38</sup> <https://www.xa.com/en/news/official/xag/77>

<sup>39</sup> <https://news.cgtn.com/news/3d3d514f3045544f34457a6333566d54/index.html>

### 3.3.7 Geomatics

#### 3.3.7.1 Everest 2020 Altimetry Team Utilise Modern GNSS Geodetic Techniques

GNSS tools are being utilised by the new **Everest 2020 altimetry team**, who are using a combination of **GNSS satellite measurement**, precision level measurements, photelectric range, snow depth radar measurements, gravity measurements, astronomical measurements, and other technological solutions to map Everest.<sup>40</sup> This **transition to integrated modern geodetic techniques is looking successful**, with Li Guopeng, the head of the first National Surveying Brigade saying that the team have reached the top of Everest.

#### 3.3.7.2 Chinese Ministry of Natural Resources Launches SkyMap 2020

A new version of **SkyMap** has achieved data integration between 31 provincial nodes, 183 municipal nodes, and national nodes across China.<sup>41</sup> This **integration updated 10 million square kilometres of remote sensing images with a 2-meter resolution**, covering all land area. It also updated 5.37 million square kilometres of remote sensing images at a 1-meter resolution or better - accounting for 61% of land area. SkyMap has also updated **819,000 items of the Catalogue of Geographic Information Resources for Surveying and Mapping**, releasing 5.17 million items in total and provided download service for the updated 1:250,000 public version of basic geographic information data such as traffic, water systems, residential areas, place names and addresses.

#### 3.3.7.3 Guizhou Achieved Three New 'Firsts' in Remote Sensing Imaging

The **Guizhou Provincial Department of Natural Resources** achieved three new firsts at the end of **2019**; a resolution of 0.2 metres for 88 administrative sites, the first full coverage of sub metre remote sensing images of in the province, and the first full coverage of two coherent radar images in the province.<sup>42</sup> **Guizhou province was traditionally the hardest province to obtain remote sensing images from**, with this advancement only being possible due to the use of aerospace remote sensing imagery as a basic data resource. This use of positional data along with the real-time acquisition of the data is one of the steps forward to the 'Big Data' development strategy.

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<sup>40</sup> <http://www.csgpc.org/bencandy.php?fid=113&id=5803>

<sup>41</sup> <http://www.csgpc.org/bencandy.php?fid=167&id=5751>

<sup>42</sup> <http://www.csgpc.org/bencandy.php?fid=113&id=4738>

## 3.4 Macro Technology Trends

### 3.4.1 Robotics

#### 3.4.1.1 New Smart Taxi Developments and Launches

Unmanned taxis seem not far from the daily life, with more and more industry players stepping in this field and starting to build up their testing sites and operations within the authorised areas, **Baidu launched in Changsha, Hunan while WeRide launched in Guangzhou, Guangdong.**<sup>43</sup>

### 3.4.2 Big Data

#### 3.4.2.1 Big Data Used to fight COVID-19

With the introduction of compulsory measures such as city closures and quarantines, China's response to the epidemic has become clear: isolate the hardest-hit areas of Hubei from the rest of the country, and then take measures on a provincial or even municipal basis to cut off the means of transmission, isolate confirmed patients and suspected cases in order to control the spread of the disease.

In the process of fighting the pandemic, **the recognition of the value of data has increased significantly**, as has the sharing and collaboration of cross-domain data, individual-oriented data services, real-time big data, etc., with the big data industry has achieved a qualitative breakthrough in several areas. Specific use cases include the use of big data to identify potentially positive coronavirus patients.<sup>44</sup>

#### 3.4.2.2 Shanghai Big Data Platform

**Shanghai Cross-Border Trade Big Data Platform** is an information platform jointly built by Shanghai Customs and shipping groups, aiming to **use big data to continuously improve the technological and intelligent level of customs supervision** services.<sup>45</sup>

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<sup>43</sup> <https://epaper.chinadaily.com.cn/a/202004/28/WS5ea78c61a3102640f4a62cc2.html>

<sup>44</sup> <https://www.huxiu.com/article/341014.html>

<sup>45</sup> <https://tech.sina.com.cn/roll/2020-04-30/doc-iirczymi9251449.shtml>

### 3.4.3 Digitalisation and AI

China's AI companies are not yet organised into a coherent, unified sector, instead they are fragmented with few connections between them. The market has begun to combat this, with Chinese companies beginning to form a more vertically integrated industry. Market leaders such as Tencent, Alibaba, Baidu, and Huawei have started to utilise their own data, technologies, algorithms, and server to provide a support platform for the smaller players in the market.<sup>46</sup>

### 3.4.4 Sharing Economy

The market size of China's sharing economy exceeded 3.2 trillion yuan (EUR 400 billion) in 2019, growing by 11.6 percent year on year according to a recent development report.<sup>47</sup> In 2019, about 800 million people in China participated in the sharing economy, of which about 78 million were service providers according to the Sharing Economy Research Centre.

#### 3.4.4.1 HIVE Box Launches Mutual Aid Mask System

HIVE have launched a 'Mask Mutual Aid' sharing system to fight against the coronavirus, where Citizens can make "donations" and "requests for donations" through the "Mask Support" function. Donations are being conducted through the 'Smart Cabinet' app in WeChat, where mask information, collection, and donations are facilitated through the app.

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<sup>46</sup> <https://www.iimedia.cn/c1020/66006.html>

<sup>47</sup> <https://www.chinadaily.com.cn/a/202003/05/WS5e60af5ea31012821727ca27.html>

## 4 Taiwan

### 4.1 Introduction

Taiwan holds a significant position in the global GNSS industry value chain, being **home to some of the largest chip manufacturers and semiconductor board integrators**. Taiwan is perfectly located to reap the benefits of a multi-GNSS environment, with access to several global and regional services. The Taiwanese industry is characterised by its swift reaction to industry trends, with a current focus on consolidating opportunities in consumer solutions, automotive, smart transportation, electronics and IoT.

With an unparalleled foundation in hardware manufacturing, Taiwanese companies move on to the **growing integration of hardware and software**, especially when it comes to 5G, AI, IoT, big data, and industry 4.0. New opportunities abound as digital marketing and e-commerce mature, Taiwan has been shaping up well with many start-ups developing in a variety of cross-domain smart tech solutions, such as integrating 5G telecom infrastructure, diverse sensor-based IoT equipment, blockchain and AR/VR/MR applications.

Segment		Key Trends
Upstream		Weather and remote sensing <b>satellites development</b> , using <b>GNSS reflectometry</b>
Market Trends	Consumer Solutions	Digital technologies to <b>fight COVID-19</b> and developments in mobile payment systems
	Road Transportation & Automotive	Growing use of <b>multi-GNSS in RTK, Dead-Reckoning, and automated driving technologies</b>
	Drones	<b>High-precision and high payload drones</b> for commercial and recreational use
	Agriculture	Ag-senor with on-board GPS and drones for <b>soil analysis, planting, fertilizer and pesticide spraying, crop monitoring</b>
	Geomatics	The <i>e-GNSS</i> <b>RTK positioning system starts to use Galileo signal</b>
	Critical Infrastructures	Telecom company's 5G development
Macro Technology Trends	Robotics	Using <b>delivery</b> and service <b>robots</b> to fight COVID-19
	Big Data	Using Big Data technology for <b>COVID-19 monitoring</b>
	Digitalisation and AI	Taiwan as <b>AI R&amp;D hub</b> with joint force from public and private
	Silver Economy	eHealth applications for the emerging super-aged society
	Cyber Security	Development of a new cyber security defender that is capable of detecting false GNSS messages
	Sharing Economy	<b>Growing market</b> in bike, motorcycle and car <b>sharing applications</b>

## 4.2 Upstream Developments

### 4.2.1 Satellites

The third-phase of Taiwan's Long-term National Space Technology Development Program focuses on satellite development, and will run from 2019 to 2028. An estimated NT\$25.1 billion (EUR 773.7 million) will be invested throughout the decade to **push domestic aerospace technology to new heights and meet the challenges of cutting-edge space missions**. At the same time, the program also aims to extend and spread the benefits of the aerospace technology industry, nurture space technology talent, and build a domestic aerospace industry supply chain. The program aims to develop **6 High Resolution Remote Sensing Satellites, 2 Ultra-high Resolution Remote Sensing Satellites** and **2 Synthetic Aperture Radar Satellites**.<sup>48</sup>

Taiwan's National Space Organisation (NSPO) aims to launch **Taiwan's second domestically developed weather satellite**, Triton, in the second half of 2021 by French firm Arianespace at a base in French Guiana.<sup>49</sup> The **Global Navigation Satellite System Reflectometry (GNSS-R)** — as well as other critical components, such as the onboard computer, the power control unit, the GPS receiver and a fibre-optic gyro, were developed by NSPO personnel.

## 4.3 GNSS Market Trends

### 4.3.1 Consumer Solutions

Taiwan holds a significant position in the global GNSS industry value chain, being **home to some of the largest chip manufacturers and semiconductor board integrators**. Taiwan is perfectly located to reap the benefits of a multi-GNSS environment, with access to global and regional services.

#### 4.3.1.1 Growing use of Digital Technologies to Fight COVID-19

In Taiwan, a mobile phone-based **electric fence** uses location-tracking **to ensure people who are quarantined stay in their homes**.<sup>50</sup> If the patient leaves their home address or turns off their smartphone, **the police will visit within 15 minutes**.<sup>51</sup>

Taiwanese citizen developers also built a digital, **real-time map of mask stocks** at pharmacies, and the government quickly reached out to collaborate.<sup>52</sup>

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<sup>48</sup> <https://english.ey.gov.tw/News3/9E5540D592A5FECD/46f4d4cc-ccea-4d22-874e-ecb93e5cf1b8>

<sup>49</sup> <http://www.taipeitimes.com/News/taiwan/archives/2019/11/17/2003726007>

<sup>50</sup> <http://www.straitstimes.com/asia/east-asia/coronavirus-taiwans-new-electronic-fence-for-quarantines-leads-wave-of-virus>

<sup>51</sup> <http://www.qz.com/1825997/taiwan-phone-tracking-system-monitors-55000-under-coronavirus-quarantine/>

<sup>52</sup> <http://www.taiwannews.com.tw/en/news/3882111>

SANAV's real-time tracking products support governmental efforts to create **electronic monitoring applications for COVID-19 prediction** models.<sup>53</sup>

STARWING Intelligent Indoor Positioning System (room-level accuracy) helps to **track people's movements in commercial buildings** by **providing data of the target people's contact history** and trajectory reproduction.<sup>54</sup>

#### 4.3.1.2 Growing Presence of Mobile Payment Systems

Taiwan's mobile payment penetration rate **surged from 24.4 percent in 2016 to cross the 50 percent mark in 2018, reaching 62.2 percent in 2019.**<sup>55</sup> In 2019, the government set up **three strategies to popularize mobile payments**, aiming to enhance transaction convenience, expand opportunities for the its use and to enhance the consumer experience.<sup>56</sup>

The competition between mobile-wallet businesses is intensifying as **consumers increasingly settle transactions with their smartphones**. Convenience stores still do not take credit cards, but they do increasingly welcome mobile payments. Digital wallets from Apple Pay and Google Pay to homegrown JKoPay and Japan's LinePay are now **widely accepted at the major convenience-store chains**. Consumers pay for a transaction either by swiping their phones over a contactless terminal or scanning a QR code provided by the merchant. The government has set a **goal of 90% mobile-payment penetration by 2025.**<sup>57</sup>

#### 4.3.1.3 Growing Market of e-Commerce

With the rise of e-Commerce, smart logistic centres have become popular in Taiwan. Among them, Logistic Republic attracts many international customers, including DHL and Decathlon. The warehouse **provides automated equipment**, such as AGV, an **automated storage and retrieval system (AS/RS)** to fulfil customers' needs.<sup>58</sup>

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<sup>53</sup> [http://www.sanav.com/news-detail/hot-covid-19\\_electronics-monitoring-applications.htm](http://www.sanav.com/news-detail/hot-covid-19_electronics-monitoring-applications.htm)

<sup>54</sup> <https://www.starwing.com.tw/en/news/36>

<sup>55</sup> <http://www.taiwannews.com.tw/en/news/3861779>

<sup>56</sup> [english.ey.gov.tw/News3/9E5540D592A5FECF\3881a49e-1077-4bcd-8542-a1d29e5b7358](http://english.ey.gov.tw/News3/9E5540D592A5FECF\3881a49e-1077-4bcd-8542-a1d29e5b7358)

<sup>57</sup> <https://topics.amcham.com.tw/2019/05/taiwans-mobile-payments-market-heats-up/>

<sup>58</sup> <http://www.logisticrepublic.com/en/>



## 4.3.2 Road Transportation & Automotive

### 4.3.2.1 Growing use of Multi-GNSS in RTK and Dead-Reckoning

SkyTraq introduced its S1216DR8P **GPS/GNSS dead-reckoning receiver**, integrating a 3-axis gyroscope, 3-axis accelerometer, **and barometric pressure sensor with GNSS receiver**.<sup>59</sup> SkyTraq's receivers cover GPS, GLONASS, BeiDou, Galileo, QZSS, SBAS and now cover multi-frequency high-precision GNSS.

LOCOSYS' RTK Board and RTK Algorithm Module **improved GPS and GNSS functionality**, dual-antenna-input GNSS Precise Positioning and Heading, offering **centimetre-accurate Positioning and Dead Reckoning** function workloads in automotive applications.<sup>60</sup> LOCOSYS DR Module supports **GPS, GLONASS, GALILEO, QZSS and SBAS**, and embedded MEMS sensors.<sup>61</sup>

### 4.3.2.2 Developing Automated Driving Technology

The Industrial Technology Research Institute (ITRI) and Mobiletron cooperate to **develop Taiwan's self-driving bus technology** in the next two years, teaming up with 13 supply chain manufacturers.<sup>62</sup> The rationale behind the initiative is that Taiwan's driving environment with plenty of motorcycles is **more complicated than the international norm, rendering foreign systems hardly usable in Taiwan**. This has a strategic edge, as ITRI is already eyeing markets with similar road conditions in Southeast Asia.

C-V2X technologies also continue to develop in Taiwan. SANAV launches cutting-edge **C-V2X antennas for automatic vehicle navigation** and high signal receiving ability with support of GNSS.<sup>63</sup>

DEKRA provides the **testing of two major V2X communication technologies DSRC and C-V2X** exclusively in Taiwan. DEKRA also releases the **testing of eCall based on EU standards**, as its only one TIC supplier in Taiwan.<sup>64</sup>

<sup>59</sup> [http://www.skytraq.com.tw/homesite/blog-widget/skytraq-introduces-two-in-one-gps-gnss-dead-reckoning-receiver?send\\_to=%2Fhomesite%2Fuser-login-register](http://www.skytraq.com.tw/homesite/blog-widget/skytraq-introduces-two-in-one-gps-gnss-dead-reckoning-receiver?send_to=%2Fhomesite%2Fuser-login-register)

<sup>60</sup> <http://www.locosystech.com/en/category/RTK-Embedded-board.html>

<sup>61</sup> <https://www.locosystech.com/en/product/dr-module-mc-1612-dg.html>

<sup>62</sup> <https://en.ctimes.com.tw/DispNews.asp?O=HK41251PE3MSAA00NG>

<sup>63</sup> <http://www.sanav.com/news-detail/sanav-launches-cutting-edge-c-v2x-antennas.htm>

<sup>64</sup> <http://www.digitimes.com/news/a20200428PD212.html&chid=9>

## 4.3.3 Drones

### 4.3.3.1 New Regulations on Drones

In **Taiwan**, **drones have been widely used** in soil and field analysis, planting, fertilizer and pesticide spraying, crop monitoring, inspections on electric power, forest, and national land, disaster prevention, environmental monitoring and so forth.<sup>65</sup> GNSS use for Taiwan's self-made UAVs is currently limited to GPS and GLONASS. The use of **commercial and recreational drones is growing rapidly in Taiwan and promises major economic benefits** to the telecom, and industrial goods industries. In response, **Taiwan's Civil Aeronautics Administration recently updated its drone use regulations**, requiring increased drone registration and inspection.<sup>66</sup>

### 4.3.3.2 Growing use of High-Precision and High-Payload Drones

Taiwan's drone manufacturers are mostly SMEs. Taiwan's key UAV manufacturers, including GEOSAT Aerospace & Technology, Thunder Tiger Technology and Coretronic Intelligent Robotics have developed **intelligent unmanned drones for surveillance and maintenance**.<sup>67</sup> These companies apply technologies such as Position and Orientation System (POS), RTK, ultrasonic and laser sensors for accurate positioning. **CIRC plans to offer high-precision and high-payload surveillance drone solutions** for diverse commercial use in the first half of 2020.

HJUAV began its logistic drone project in 2018. Its drone so far has **successfully delivered goods to remote counties in Tainan and Ali Mountain area**.<sup>68</sup>

### 4.3.3.3 Growth of Drone Integration Solutions for UTM

Companies in ITS, Telematics and GIS industries have started to **develop more innovative and emerging smart-city applications** and practices. For example, TMS Technologies has recently partnered with AirMap to supply **drone integration solutions for UTM/U-Space in Taiwan**.<sup>69</sup>

## 4.3.4 Agriculture

Taiwan is pushing itself as a hub for Agriculture 4.0 and trying to grow relevant start-ups, SMEs and system integrators. The agri-tech start-up Soiltech Wireless' ag-sensor measures **moisture, temperature, humidity and bruising**, which is wirelessly transmitted to users with an **on-board GPS module** to provide location-specific information.<sup>70</sup>

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<sup>65</sup> <https://gnss.asia/blog/market-analysis-the-gnss-based-development-of-the-taiwans-drone-industry-the-case-study-of-taiwan/>

<sup>66</sup> <https://drone.caa.gov.tw/en-US/Default/DataDetail3/8>

<sup>67</sup> <http://www.digitimes.com/news/a20191211PD217.html>

<sup>68</sup> <http://www.hjuav.io/copy-of>

<sup>69</sup> <http://www.unmannedairspace.info/latest-news-and-information/airmap-partners-with-tms-technologies-to-offer-drone-integration-solutions-in-taiwan/>

<sup>70</sup> <http://www.soiltechwireless.com/>

Current agricultural UAV applications focus on **establishing the characteristics of spray systems suitable for different types of drones and crop**, and evaluating the safety of pesticide dosages. Developments are ongoing with regards to **low-altitude and low-volume drones' technology for plant protection** in Taiwan.<sup>71</sup>

The start-up Aeroprobing Inc. provides UAV control systems and integrated applications. The company also **developed Ground Controlling Software and a UAV artificial intelligence system**. The AG1-Octo **agricultural spray drone** has been successfully introduced into the Southeast Asian market, where the firm works with locals to develop the agricultural UAV service industry.<sup>72</sup>

### 4.3.5 Geomatics

In Taiwan, the National Land Surveying and Mapping Centre (NLSC) is **developing high definition maps with NLSC's e-GNSS system**. A total of 78 online real-time service base stations in the system obtain high precision positioning results in coordination with the **VBS-RTK (Virtual Base Station Real-Time Kinematic) technology**.<sup>73</sup> The core software of e-GNSS is capable of processing GPS and GLONASS data, although some base stations **can receive GPS, GLONASS, BeiDou and Galileo signals**.

### 4.3.6 Critical Infrastructure

Taiwan's largest telecom service provider **Chunghwa Telecom selected Ericsson for a rapid 5G build-out in Taiwan**, which will deploy a non-standalone (NSA) New Radio (NR) network on mid and high-frequency bands.<sup>74</sup> It will use Ericsson Radio System base stations and Ericsson's 5G Core, including 5G Evolved Packet Core.

## 4.4 Macro Technology Trends

### 4.4.1 Robotics

Taiwan's delivery **robots are well used to address the COVID-19 outbreak**.<sup>75</sup> The Automated Guided Vehicle (AGV) technology has been developed for many years, such as the TECO's Enviro Robot for food delivery or tray recovery, imedtac's iMVS-AIO robot for medicine and medical devices delivery, **Qisda's smart medical delivery robot Mibot which carries waste transportation**, and Geosat's M01 intelligent handling robot.

The reception robots can be used, **through image recognition and voice interaction, to provide registration advice to the visitor**, and at the same time to perform preliminary patient shunting

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<sup>71</sup> [https://ap.fftc.agnet.org/ap\\_db.php?id=1081](https://ap.fftc.agnet.org/ap_db.php?id=1081)

<sup>72</sup> [http://www.taiwanagriweek.com/edm/201908/en\\_aeroprobing.html](http://www.taiwanagriweek.com/edm/201908/en_aeroprobing.html)

<sup>73</sup> <http://www.nlsc.gov.tw/En/MakePage/492?level=492>

<sup>74</sup> <https://www.ericsson.com/en/press-releases/2020/3/chunghwa-telecom-selects-ericsson-for-rapid-5g-build-out-in-taiwan>

<sup>75</sup> [http://www.tairoa.org.tw/column/column.aspx?column\\_id=3711&column\\_type\\_id=1](http://www.tairoa.org.tw/column/column.aspx?column_id=3711&column_type_id=1)

and screening for medical staff, combined with thermal imaging technology, body temperature sensing camera, through audio alarm, video alert to further monitor epidemic prevention. These robots include Syscom's Ayuda, Perobot's Pepper, Geosat's C01, and QNAP's AfoBot.

MSI also developed "AI-UVC **Disinfection Robots**" as the workstation of medical staff and **performs the duty of disinfection and cleaning at any moment**.<sup>76</sup> Smart Patrol Robots built with Advantech's UNO-2484G Edge Gateway were **deployed to fight the Coronavirus**.<sup>77</sup>

Other developments in robotics include:

- Syscom's adoption of **CyberLink facial recognition technology** in Ayuda service robot.<sup>78</sup>
- ITRI **new AI and robotics technologies**, including a Mobile Arm Robot System, AI Camera for Baby Care, Robots with Smart Joints, Mechavision Tactile Sensing Technology, Cloud Gaming System, and Micro LED Technology.<sup>79</sup>

#### 4.4.2 Big Data

In response to COVID-19, **Taiwan leveraged its national health insurance** database and integrated it with its immigration and customs database to begin the creation of big data for analytics. It generated **real-time alerts during a clinical visit** based on travel history and clinical symptoms to aid case identification.<sup>80</sup> It also used new technology, including QR code scanning and online reporting of travel history and health symptoms to classify travellers' infectious risks based on flight origin and travel history in the past 14 days. **Persons with low risk were sent a health declaration border pass via SMS messaging to their phones for faster immigration clearance**; those with higher risk were quarantined at home and tracked through their mobile phone to ensure that they remained at home during the incubation period.

#### 4.4.3 Digitalisation and AI

Taiwan's government wants **to turn the island into a hub of AI R&D**. Taiwan has been the world's hardware hub for decades, so the shift toward AI makes the most of the existing inexpensive engineering talent. A refocus on AI, however, reduces reliance on hardware, which can easily be made somewhere else, such as China, at lower costs.

Multinational tech companies have already **shown interest in tapping Taiwan's talent in software, including AI**. Taiwan is opening a giant **AI-focused business park in Hsinchu** close to one of Taiwan's major all-purpose high-tech zones and two top universities.<sup>81</sup>

<sup>76</sup> <http://www.msi.com/news/detail/a412963e013751a90654aa344bc26efe>

<sup>77</sup> <http://www.advantech.com/resources/news/smart-patrol-robots-built-with-advantech%E2%80%99s-uno-2484g-edge-gateway-deployed>

<sup>78</sup> <http://www.biometricupdate.com/201902/syscom-integrates-cyberlink-facial-recognition-tech-in-ayuda-service-robot>

<sup>79</sup> <http://www.businesswire.com/news/home/20191211005271/en/ITRI-Showcases-AI-Robotics-Technologies-CES-2020>

<sup>80</sup> <http://www.jamanetwork.com/journals/jama/fullarticle/2762689>

<sup>81</sup> <http://www.forbes.com/sites/ralphjennings/2020/01/27/taiwan-is-opening-a-giant-ai-focused-business-park/#c48e161c08a2>

The Ministry of Science and Technology (MOST) announced in its AI scientific research strategy in 2017, striving to **evolve Taiwan into a heavyweight in AI development** and making Taiwan among the first nations that have already announced and made AI their national strategy. **Taiwania 2**, a supercomputer specifically built for AI, offers its cloud service through TWCC (Taiwan Computing Cloud).<sup>82</sup>

Taiwan AI start-ups **utilising the integration of software and hardware**, AI applications, big data from cameras, and WiFi measurement include SkyREC, Cubo, Lucid and NUWA Robotics. Among them, Umbo Computer Vision **specialises in intelligent security monitoring and develops image recognition technology with self-learning and analytic capabilities**.<sup>83</sup> The company has successfully entered the European and American markets.

Ganzin Technology's Eye Tracking Module **combines the virtual and real world**, and replaces the hand-operated user interface, allowing users to control devices with their eyes.<sup>84</sup>

Advantech keeps the leading AI position **by launching AI facial recognition Edge SRP for Intelligent city service applications**.<sup>85</sup> Advantech integrates its WISE-PaaS, edge intelligence, AI and other solutions into an overall framework in order to establish the AIoT link to simplify the process of edge-to-cloud AI-powered industrial IoT application.<sup>86</sup>

#### 4.4.4 Silver Economy

Taiwan became an 'aged' society in 2018, when the proportion of its population aged over 65 surpassed 14%. It is **expected to become a 'super aged' society by 2026** (with more than 20% of its population in this age group), making it **one of the fastest-ageing societies in the world**. The rapid development and uptake of digital-health products and services has driven an interest in **mobile diagnostics, wearables, remote monitoring and internet-connected medical appliances**.<sup>87</sup> In addition, the government's newly enacted **Long Term Care 2.0 (LTC 2.0) policy** is directing resources and funds towards 'ageing in place', where an elderly person remains in their house for as long as possible, supported by community resources.

Compared with the government's focus on the **establishment of the long-term service system**, the development of the private silver industry is more diverse. The private silver economy has become increasingly active, especially driven by several **large-scale senior living and continuing-care retirement community cases**.<sup>88</sup> Advantech offers an **RFID-based Medication Tracking Solution**.<sup>89</sup>

<sup>82</sup> <http://www.nchc.org.tw/Message/MessageView/3378?mid=92&page=1>

<sup>83</sup> <http://www.meet.bnext.com.tw/intl/articles/view/45543>

<sup>84</sup> <http://www.yahoo.com/news/ganzin-technologys-eye-tracking-module-160000800.html>

<sup>85</sup> <http://www.advantech.com/resources/news/%E3%80%90new-product-announcement%E3%80%91advantech-launches-ai-facial-recognition-edge-s>

<sup>86</sup> <http://www.advantech.com/resources/industry-focus/edge-to-cloud-integration-framework-eis-wise-paas-deviceon-ai-aiot>

<sup>87</sup> [http://www.tiq.qld.gov.au/download/industrysector/knowledge-industries/TIQ5720-TIQ-IMR\\_Taiwan-Aged-care\\_v11.pdf](http://www.tiq.qld.gov.au/download/industrysector/knowledge-industries/TIQ5720-TIQ-IMR_Taiwan-Aged-care_v11.pdf)

<sup>88</sup> <http://www.silvereco.org/en/experts-talking-silvereco-give-the-floor-to-tang-chieh-lang-specialist-in-long-term-care-and-financial-services-in-taiwan-market/#more-31478>

<sup>89</sup> <https://advcloudfiles.advantech.com/ecatalog/2020/03270849.pdf>

### 4.4.5 Cyber Security

ARCRAN offers the *V2X/loV Joint Cyber Security Defense iSecV Detector*, which is an isolated add-on box, used to detect DSRC / C-V2X signals, and **to analyse un-approved signal sources using the whitelisting mechanism**. In addition, it is able to **detect abnormal behaviours**, for example, Tampering of data in transit (MitM), jamming (Denial of Service) of communication channels, spoofing of signals, **spoofing of GPS messages** (including coordinates, time, signals), by using machine learning methods. iSecV will be placed inside the Buses and RSUs, and communicate with the Traffic Centre through an independent 4G Channel.<sup>90</sup>

### 4.4.6 Sharing Economy

The sharing economy has grown with prevalent phone use, and it is slowly making its way in Taiwan. Numerous **county and city governments have begun actively promoting the sharing economy**, including YouBike, U-Motor and U-Car. The Coronavirus outbreak also made the services popular for keeping social distancing. WeMo went into partnership with KYMCO, a major Taiwanese manufacturer of motorcycles, and in 2016 launched **shared electric scooters, which so far are available in Taipei**.<sup>91</sup> The App shows battery status and scooter locations, supports online booking and unlock key.

The competing electric scooter brand, Gogoro, **creates the world's first end-to-end mobility sharing platform GoShare to support cleaner and smarter cities**.<sup>92</sup> The team at Gogoro integrated 3 core urban mobility elements: Gogoro Smartscooter, Gogoro Network™ and GoShare software solutions.

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<sup>90</sup> <http://www.arcran.com/index.html>

<sup>91</sup> <http://www.wemoscooter.com/>

<sup>92</sup> <http://www.ridegoshare.com/us/>

## 5 South Korea

### 5.1 Introduction

South Korea is preparing for its leap forward in both upstream and downstream space industries. Between 2019 and 2021, a few satellite launches are scheduled in addition to the **completion of its KASS SBAS system**. New space assets will provide upgraded capabilities for GNSS as well as various types of data - meteorological, environmental, and imagery.

The Korean government has announced its ambition to **lead autonomous driving technologies** and boost the **drone market**. It is worth paying attention as to whether the government's initial push will lead to sustainable market development.

Meanwhile, the global **COVID-19 pandemic** has made an immediate and significant impact on the daily lives of Korean citizens. South Korea has been successfully containing the outbreak, employing **IT technologies, including GNSS**. The COVID crisis has also enabled to unlock the potential of untapped digital technologies.

As much as technology, GNSS penetration and digital convergence rely heavily on the regulatory framework. Despite its technological prowess, South Korea has often been considered as a tightly regulated market that stifles innovation. There are differing signs regarding the **legal and regulatory context**, as privacy laws have been revised to embrace the business use of personal information while the country's prominent ride-hailing service banned by another revision.

Segment		Key Trends
<b>Upstream</b>		The upstream sector is expanding <b>with new satellite launches</b> and infrastructure building, including the KASS SBAS system.
<b>Market Trends</b>	Consumer Solutions	COVID crisis <b>enables LBS applications</b> and e-health solutions previously unavailable.
	Road Transportation & Automotive	<b>EUR 830 million investment</b> into a framework for the development of an <b>autonomous driving ecosystem</b> Hyundai unveiled the <b>City of the Future concept</b> with autonomous vehicles as part of it
	Manned Aviation	Manned/unmanned personal air vehicles under <b>conceptual development</b>
	Drones	Initiatives by the public sector for <b>initial market development</b>
	Rail	Interest in GNSS-based rail traffic system continues
	Agriculture	GNSS-aided lane maintenance solutions for <b>rice-planting machine</b>
	Geomatics	<b>National Land Satellite Centre opened</b> in November 2019



Segment	Key Trends	
Macro Technology Trends	Robotics	<b>Autonomous delivery robots</b> will be tested in 2020
	Big Data	<b>Amendments to 3 major privacy laws</b> are encouraging data business opportunities
	Climate Change	Newly <b>launched environmental monitoring satellite</b> will contribute to climate change monitoring efforts
	Sharing Economy	<b>Car and scooter sharing boosted</b> with the COVID situation. Regulation banned a van ride-hailing service.

## 5.2 Upstream Developments

### 5.2.1 Government Plans for Space Development in 2020

The Korean government announced plans to spend KRW 616 billion (EUR 466 million) on space projects in 2020. The budget increased by 6.4% from 2019 as the country **prepares to launch its first domestically built rocket** and **a new medium-size satellite and develop two Multi-Purpose Satellites (KOMPSATs)**. More than one-third of the investment will go to the Nuri launch vehicle, the indigenous rocket equipped with 75-tonne thrust engine, and the half of the budget will be spent on Korea's first 500kg-class satellite and 2 KOMPSATs development.<sup>93</sup>

In addition, “the Space Pioneer” project has recently passed a preliminary feasibility study. The project spends KRW 211.5 billion (EUR 160 million) over 10 years from 2021 and aims to **increase the use of domestic parts in space systems**.<sup>94</sup> To build a reliable supply chain and boost relevant industries, the government will first invest in localising 16 essential parts in launch vehicles and satellites.

### 5.2.2 KPS and KASS developments moving forward

**Satellite navigation programmes are cruising as planned.** The **Korea Positioning System (KPS)**, a local navigation satellite system worth of KRW 3 trillion (EUR 227 million), will go through a **preliminary feasibility study** in the first half of 2020. Once the project passes this initial assessment, it will kick off in 2022 with the goal of **full system operation in 2034**. On the other hand, a detailed design for the Korean SBAS (**KASS**) will be completed in June 2020, and system integration is expected to begin from November.<sup>95</sup>

<sup>93</sup> <https://en.yna.co.kr/view/AEN20200307002500320>

<sup>94</sup> [https://www.msit.go.kr/web/msipContents/contentsView.do?catelId=\\_policycom2&artId=2851079](https://www.msit.go.kr/web/msipContents/contentsView.do?catelId=_policycom2&artId=2851079)

<sup>95</sup> <http://www.businesskorea.co.kr/news/articleView.html?idxno=39807>

## 5.3 GNSS Market Trends

### 5.3.1 Consumer Solutions

In February, the Korea Internet & Security Agency (KISA) released an annual survey **report about the location-based solutions industry** in 2019, with the input from 992 participating companies.

In 2019, the estimated turnover of the whole industry was KRW 1.59 trillion (EUR 12 billion), a 7.9% increase compared to that of 2018. It also projected a **15.9% increase in 2020 should the growth pattern continue**. Of products, **tracking solutions** accounted for 46% (KRW 738.6 billion), followed by **lifestyles and entertainment** (KRW 300 billion), maps & navigation apps (KRW 159 billion), and geo-marketing & advertising (KRW 136 billion).

However, in light of sectoral growth, **big data analysis** showed the most outstanding spike (68.4%) with **maps & navigation** (22.9%) as a distant second. Furthermore, 65.4% of those surveyed selected big data as the most promising sector, while estimating transportation and distribution would be most beneficial in incorporating location information.<sup>96,97</sup>

#### 5.3.1.1 COVID-19 Response

The first quarter of 2020 was **dominated by the explosive spread of the COVID-19 coronavirus**. Although South Korea had been among the most affected countries at the initial phase until February, it successfully turned the tide with its aggressive testing and **extensive use of ICT and GPS tracking**. By late March, South Korea's response to COVID-19 was considered exemplary and became one of the most important case studies in handling the outbreak.

The Korean government has effectively employed **GNSS tracking to monitor confirmed patients and warn the public of the places visited by patients** and confirmed carriers. Various public and private apps have been developed for these purposes, with the government-built **Self-Quarantine app** enforcing quarantine via an alarm if the patient leaves a designated quarantine area.

Privately developed apps such as **Now and Here** calculates a mix of risk factors in surrounding areas when users enter their commuting routes. If users record their own routes, the app compares the user's paths with those previously taken by confirmed patients. If the user has been at the same place as a confirmed patient at a similar time, the app suggests when and where testing is available. Similarly, **Cobaek** (the name indicates Corona and 100m in Korean) **sends an alarm when users are within 100 meters of a place that a confirmed patient visited**, with a premium version **adding alerts for the availability of publicly provided masks at pharmacies**.<sup>98</sup>

<sup>96</sup> [https://www.kisa.or.kr/public/library/lbs\\_View.jsp?mode=view&p\\_No=281&b\\_No=281&d\\_No=86&cPage=&ST=TC&SV=](https://www.kisa.or.kr/public/library/lbs_View.jsp?mode=view&p_No=281&b_No=281&d_No=86&cPage=&ST=TC&SV=)

<sup>98</sup> [http://www.moj.go.kr/moj\\_eng/1765/subview.do;jsessionid=3MYSRzN0s\\_keUcwLBTNrpPxRgm2geal\\_C7Fx6Pht.wizard-10-v4gmk?enc=Zm5jdDF8QEB8JTJGYmJzJTJGbW9qX2VuZyUyRjUxJTJGNtlyODIyJTJGYXJ0Y2xWaWV3LmRvJTNG](http://www.moj.go.kr/moj_eng/1765/subview.do;jsessionid=3MYSRzN0s_keUcwLBTNrpPxRgm2geal_C7Fx6Pht.wizard-10-v4gmk?enc=Zm5jdDF8QEB8JTJGYmJzJTJGbW9qX2VuZyUyRjUxJTJGNtlyODIyJTJGYXJ0Y2xWaWV3LmRvJTNG)

### 5.3.1.2 Emerging eHealth Applications

The COVID-19 outbreak has been shaking traditional business rules and regulations across the globe. In South Korea, it may have a lasting impact on the **telemedicine and wearable healthcare** industries which have been one of the main industries affected by the change.

The COVID-19 crisis that has resulted in social distancing is challenging the traditional position, and there are signs of change. The **government temporarily suspended regulations and allowed remote treatment to avoid unnecessary contact** amid the COVID crisis. Then, **Medihere**, a digital healthcare start-up, introduced the country's first remote-treatment application.<sup>99</sup> Moreover, thanks to the government's "regulatory sandbox" - a mechanism to speed up innovation by relaxing the existing regulations, **Huinno** received permission and develop a wearable electrocardiogram, leading to immediate investment from Yuhan Co., Ltd, a Korean pharmaceutical company.<sup>100</sup>

It is too early to tell the prospect of South Korea's eHealth market, yet it is worth paying attention as tight regulations are likely to loosen up with ICT and GNSS technologies waiting to be utilised.

## 5.3.2 Road Transportation and Automotive

### 5.3.2.1 Autonomous Driving and Mobility as a Service Pilot Projects Announced

South Korea has **an eye on autonomous driving and MaaS as new industrial opportunities**, with the Ministry of Land, Infrastructure and Transport planning to start numerous pilot projects for 2020 - including **level 3 safety application from July 2020 and test driving buses in October**.<sup>101</sup>

### 5.3.2.2 Hyundai Motors 'City of the Future' Concept Unveiled

In the private sector, **the City of the Future concept Hyundai Motors unveiled at CES 2020** in January attracted considerable attention in and outside Korea. Hyundai showcased three mobility solutions - **Urban Air Mobility (UAM), Purpose Built Vehicle (PBV), and Hub, a place for mobility transfer and community activities**.<sup>102</sup> The idea of air taxis blurs the line between a drone and a vehicle, revolutionising the urban mobility system. PBVs travel autonomously but in a group (platooning) to be part of an automated highway system. It is unclear how much GNSS technologies are to be integrated, but **GNSS will likely be an integral part of the system**.<sup>103</sup>

### 5.3.2.3 Investment of € 830 Million in the Autonomous Driving Framework Project

The South Korean government are **investing EUR 830 million** in a framework project '**Autonomous Driving Technology Development Innovation Project**' – featuring 30 key missions and 84 sub-

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<sup>99</sup> <http://www.koreabiomed.com/news/articleView.html?idxno=7666>

<sup>100</sup> <http://www.koreabiomed.com/news/articleView.html?idxno=7746>

<sup>101</sup> <https://www.molit.go.kr/2020plan/info/info.jsp>

<sup>102</sup> <https://news.hyundaimotorgroup.com/Article/Hub-and-PBV-The-Essence-of-the-Future-Mobility>

<sup>103</sup> <https://www.theverge.com/2020/1/6/21048373/hyundai-flying-car-uber-air-taxi-ces-2020>

projects after **passing the preliminary feasibility study earlier this year**.<sup>104</sup> This project builds on the previous autonomous driving initiatives deployed by the government, and it is aiming to **create an entire new ecosystem in the country**, along with the development of related technologies such in segments such as IT, road and traffic management, and vehicle convergence.

### 5.3.3 Manned Aviation

The Korea Aerospace Research Institute (KARI) released a report in January to lay out its major R&D plans for 2020. In the aviation field, an **optionally piloted personal air vehicle (OPPAVs)** is on the list. An OPPAV is either manned or unmanned and can take off and land vertically.<sup>105</sup> The project will be supported by the Ministry of Transport (MOLIT) and the Ministry of Industry (MoTIE) by the end of 2023. Once complete, the **OPPAV will be an integral part of emerging Urban Air Mobility (UAM) operating in the Seoul metropolitan area**. As for navigation and surveillance, the first quarter sees few notable developments, but the KASS system is expected to upgrade the overall quality of services in the months to come.

### 5.3.4 Drones

South Korea has selected the **drone as one of the eight national priority industries**. The Basic Plan for the Drone Industry Promotion (December 2017) laid out specific targets by 2026, which included operating as many as **53,000 commercial drones**. Moreover, the ultimate blueprint for the K-drone system has been presented where an **integrated 5G-mobile network, UAS traffic management, and AI can efficiently manage drone traffic**. To boost initial demands and create a sustainable drone ecosystem, the government and the public sector have doubled down efforts to deploy drones for public services and upgrade the regulatory framework.

#### 5.3.4.1 Low Altitude Drone Communication Protocol

On 24 March, the National Radio Research Agency announced that the ISO/IEC Joint Technical Committee-1/sub-Committee-6 (system-to-system communication and information exchange) had adopted South Korea's **standardisation proposal on "low altitude drone communication protocol"** as an international standard task. The proposal is expected to be established as a standard around 2022.<sup>106</sup>

Currently, each **drone manufacturer has different communication protocols, incurring a risk of collision in the air and making it challenging to fly multiple drones simultaneously**. Thus, there have been repeated calls **for protocol standardisation**. Once enacted, a new standard would help share flight information even among a heterogeneous group of drones and prevent drones from collision or crash.

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<sup>104</sup> <https://gnss.asia/blog/koreas-ambition-to-be-a-leader-in-autonomous-driving-technologies/>

<sup>105</sup> <http://www.businesskorea.co.kr/news/articleView.html?idxno=39807>

<sup>106</sup> [https://www.msit.go.kr/web/msipContents/contentsView.do?catelId=\\_policycom2&artId=2775120](https://www.msit.go.kr/web/msipContents/contentsView.do?catelId=_policycom2&artId=2775120)

#### 5.3.4.2 R&D on Anti-Drone Technologies

Whilst promoting the drone market and technology, the Korean government is also considering developing **anti-drone measures against various threats posed by drones**.

On 7 February, the special committee for multi-ministerial collaborative R&D selected an anti-drone R&D proposal as one of the priority projects. The research proposal **aims to develop technologies for intelligent drones ("Drone Cops"), deployed to neutralise and capture attacker drones targeting the critical infrastructure of the country**.

For this project, Ministry of Science & ICT, Ministry of Trade, Energy and Industry, Ministry of the Interior Safety, and the National Police Agency will join the force.

#### 5.3.5 Rail

South Korea's Railroad Research Institute (KRRRI) assessed the feasibility of **GNSS-based rail traffic signalling and communication for railway reconnection with North Korea** in 2019. Following the inter-Korean summit in April 2018, the South Korean government has given priority to linking railways between the two Koreas. Given **massive costs in modernising the decrepit North Korean rail traffic system, the South considered a GNSS-based system as an alternative to building a whole new signal and control system** with communication infrastructure in North Korea.

However, international sanctions and North Korea's non-cooperation have stalled the plan, and it is uncertain whether the project can begin. Instead, KRRRI will **continue testing a GNSS-based rail traffic system for outdated railway sections in the South that need upgrading**.<sup>107</sup>

#### 5.3.6 Agriculture

Overall, Korea's agricultural industry is gradually shrinking. The **rice cultivation area has reduced by 17% since 2012; whereas the percentage of farm households are declining** while the (rural) population is ageing. Technology could be key to increasing profitability.

With the shortage of labour in the field, GNSS technologies **have been adopted to increase efficiency and productivity**. Yanmar Korea introduced an upgraded **rice-planting machine equipped with a GNSS-based lane control system** - model YR6D and YR8D. The machines can autonomously drive straight in lane, allowing the driver to load seedling nursery beds while driving with auto-steering turned on – reducing the workload and eliminating the second worker. Tongyang Moolsan Co., Ltd also presents a model with optional GPS-guided steering.<sup>108</sup>

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<sup>107</sup> [https://www.krri.re.kr/\\_prog/\\_board/?mode=V&code=sub06\\_0604&no=51654&site\\_dvs\\_cd=kr&](https://www.krri.re.kr/_prog/_board/?mode=V&code=sub06_0604&no=51654&site_dvs_cd=kr&)

<sup>108</sup> <http://www.kamnews.co.kr/news/articleView.html?idxno=4052>

### 5.3.7 Geomatics

Although there has been no significant development in Q1, it should be noted that **South Korea's National Land Satellite Centre opened on 1 November 2019**. The Centre was set up under the National Geographic Information Institute and will play a central role in **processing high-resolution satellite images into geospatial information** in various formats. It was established as part of a multi-year plan to launch two medium-sized satellites (KOMPSATs) in 2020 and 2021.

One of the satellites, **scheduled for launch in 2021**, will be equipped with the advanced earth imaging sensor system (AEISS) for the purpose of precision observation and provide high-quality optical images. By utilising newly acquired assets and satisfying the need for land use management, disaster response, and other public demand, the centre is expected to add great value to the country's capacity for geospatial data processing.<sup>109</sup>

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<sup>109</sup> <https://www.ngii.go.kr/eng/content.do?sq=91>

## 5.4 Macro Technology Trends

### 5.4.1 Robotics

The Ministry of Trade, Industry and Energy approved six types of new technologies and services in December 2019 for temporary regulatory exemption called the "**regulatory sandbox**." The regulatory sandbox enables innovative technologies to be **tested on a limited market before they become subject to the current laws**.

One of those technologies was an **autonomous delivery robot** developed by Robotis, Co. From 2020, the robot will be tested for its potential for food or parcel delivery on sidewalks at a limited speed.<sup>110</sup>

### 5.4.2 Big Data

The Big Data industry saw significant development regarding its regulatory framework.

On 9 January 2020, Korea's National Assembly passed **amendments to Korea's three major data protection laws** - the Personal Information Protection Act (PIPA), the Act on the Promotion of the Use of the Information Network and Information Protection, and the Credit Information Use and Protection Act.

The amendments clarify the **distinction among personal information, pseudonymised data, and anonymised information**, clearing up confusion in processing personal data. To boost data-related businesses, the amendments **introduce pseudonymised data available for statistical, research, and public purposes without explicit content and under appropriate protection**. The new laws are expected to make possible new data-based services and speed up data convergence and utilisation in new industries, including the smart city and the autonomous vehicle.<sup>111</sup>

### 5.4.3 Climate Change

Chollian-2B, launched in February, is the first geostationary meteorological satellite ahead of TEMPO (USA, scheduled for 2022) and Sentinel-4 (EU, 2023 or later). It is the **first satellite to be equipped with a Geostationary Environment Monitoring Spectrometer (GEMS) sensor**. Chollian-2B will **monitor the movement of fine dust and air pollutants that cause fine dust and climate change such as ozone, aerosol, nitrogen dioxide, formaldehyde, and sulphur dioxide**.<sup>112</sup>

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<sup>110</sup> <https://pulsenews.co.kr/view.php?year=2019&no=1063820>

<sup>111</sup> [https://www.kimchang.com/en/insights/detail.kc?sch\\_section=4&idx=20726](https://www.kimchang.com/en/insights/detail.kc?sch_section=4&idx=20726)

<sup>112</sup> [https://www.kari.re.kr/cop/bbs/BBSMSTR\\_00000000011/selectBoardArticle.do?nttId=7425&pageIndex=1&](https://www.kari.re.kr/cop/bbs/BBSMSTR_00000000011/selectBoardArticle.do?nttId=7425&pageIndex=1&)



The satellite will cover a wide area stretching from the western part of **Indonesia to southern Mongolia**, contributing to international cooperation and research on atmospheric environment. Chollian-2B is **to start providing atmospheric data from 2021**, thus, South Korea will be able to utilise the space asset in fighting climate change.<sup>113</sup>

#### 5.4.4 Sharing Economy

Overall, the sharing economy went through tough times. As the COVID crisis has made "social distancing" a new norm, **platform-based sharing businesses are suffering a visible decrease in demand**.<sup>114</sup>

Moreover, a **recently introduced regulation has put an end to Korea's own ride-hailing service**. South Korea's National Assembly passed a revised Passenger Transport Service Act in March, which will **end the van-hailing service by Tada**. The new law confirmed to **prohibit the operation of rental services with drivers who do not have a taxi license**.<sup>115</sup>

An exception to the downward trend may be more personalised mobility sharing services. In the **first quarter, car-sharing and kickboard scooter-sharing services enjoyed a steady increase in use**, while people were avoiding public transportation for fear of COVID infection.

**SoCar** saw a 50% increase in use from 1 - 15 March; **Swing** and **Kickgoing**, two most prominent scooter-sharing services also report increase during commuting time.

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<sup>113</sup> [https://www.koreatimes.co.kr/www/nation/2020/02/371\\_283704.html](https://www.koreatimes.co.kr/www/nation/2020/02/371_283704.html)

<sup>114</sup> [http://www.koreatimes.co.kr/www/biz/2020/04/175\\_288613.html](http://www.koreatimes.co.kr/www/biz/2020/04/175_288613.html)

<sup>115</sup> [https://www.koreatimes.co.kr/www/tech/2020/03/133\\_286018.html](https://www.koreatimes.co.kr/www/tech/2020/03/133_286018.html)

# 6 Japan

## 6.1 Introduction

Japan's has a number of specific features compared to most other GNSS markets. The country has **indigenously developed its GNSS constellation (Michibiki aka QZSS) as well as its SBAS named "MSAS"**. Its domestic electronics industries necessary for manufacturing receivers is largely self-sufficient and does not have strong technological motivation to import from overseas. As a result, market entry barriers are very high.

In order to identify what kind of products or services are accepted by the market, the recommended best way for foreign enterprises to access the market might be a "roundabout" approach described like "the longest way about is the nearest way to the destination." Therefore, this chapter **concentrates on the historical context and underlying Japanese governmental policies which steer and regulate Japan's GNSS market.**

*Most of the used sources about Japan's domestic policies are intended for a Japanese audience and are hence not available in English. We do refer to these sources, and suggest the use of a browser-embedded translation function. This language barrier may be the strongest market access obstacle into Japan.*

Segment		Key Trends
<b>Upstream</b>		1st QZSS was launched in 2011, the official service started in November 2018 with 4 satellites, and a <b>7-satellite constellation will be completed in 2023.</b>
<b>Market Trends</b>	Consumer Solutions	Governmental focus on <b>GIS and Indoor Positioning</b>
	Road Transportation & Automotive	MLIT has revised the law in 2019 to accommodate <b>Level-3 and Level-4.</b> JEITA establishes <b>standard specifications for in-vehicle equipment for QZSS Disaster Alert.</b>
	Manned Aviation	JCAB proceeds CARATS in coordination with SESAR in EU and NextGen in USA.
	Drones	JCAB has been legislating <b>regulations necessary for promoting drones.</b>
	Maritime	QZSS will be approved by IMO as one of the <b>official GNSS constellations for maritime vessels.</b>
	Emergency Response	<b>"eCall" has become mandatory equipment</b> for new models since Jan 1st 2020
	Rail	<b>Fail Safe system is a must</b> for Train Controls by GNSS to be accepted in Japan.
	Agriculture	MAFF concentrates on <b>demonstrative pilot projects of Smart Agriculture.</b>

Segment		Key Trends
Macro Technology Trends	Geomatics	Basic Act, Basic Plan, & Timeline of Advancement of Utilizing Geospatial Information
	Critical Infrastructures	Time Standards are <b>better maintained domestically than UTC</b>
	Robotics	World Robot Summit/Competition 2020 to be postponed to 2021
	Big Data	Pseudonymised Processed Personal Information has just legislated.
	Digitalisation and AI	<b>Rapid Image Analysis</b> is the most popular application of Deep Learning.
	Climate Change	<b>GNSS precipitation data</b> has been used for daily weather forecast since 2009.
	Silver Economy	Quantitative Goals: SAE Level-4 by 2025, Nursing-Care Robots with 50B JPY
	Cyber Security	7-satellite QZSS might have a <b>Message Authentication function</b> .
	Sharing Economy	Sharing Economy Promotion Office has submitted a draft of ISO Standards.

## 6.2 Upstream Developments

### 6.2.1 QZSS

Japan's regional QZSS constellation is relatively unique. First, **QZSS complements GPS** by transmitting the same signal on the same frequency from the quasi-zenith direction in order to improve reception especially in urban canyons. Second, QZSS transmits several kinds of **free high-accuracy augmentation signals such as SLAS, CLAS, MADOCA, and MSAS** directly from the satellites. Third, QZSS has a **short message broadcasting function** named "Disaster & Crisis Alert" in case for national or regional emergency.

Although its first satellite was launched in 2011, QZSS has started its **official services in November 2018**, and will evolve from its current 4-satellite constellation to the **final form of 7-satellite constellation** in order to ensure independence as a satellite positioning system and improved performance with wider coverage of the Asia Pacific region by 2023.

A recent survey launched by SPAC and QBIC revealed how well this QZSS has been accepted by the Japanese market.<sup>116</sup> A considerable uptake of QZSS was seen in B2B professional markets, such as construction, survey, agriculture, etc. thanks to demonstrations promoted by various private sectors using its high accuracy augmentation services since just after the first QZSS launched in 2011. QZSS users prioritise the reliability of services and are waiting for lower-cost receivers compatible with QZSS's augmentation signals.

## 6.2.2 RTK Services of Mobile Providers

Japan's three major mobile carriers NTT DoCoMo, KDDI (au), and SoftBank, have started high accuracy RTK services with very affordable pricing by using their own mobile cell tower networks and/or the national CORS network maintained by Geospatial Information Authority of Japan (GSI) with supports from their partner companies, as well as to offer positioning solutions on the cloud.

Oct 1 <sup>st</sup> 2019 :	NTT DoCoMo <sup>117</sup>	&	Lighthouse Technology & Consulting
Nov 30 <sup>th</sup> 2019 :	SoftBank <sup>118</sup>	&	Enabler Ltd.
Apr 24 <sup>th</sup> 2020 :	KDDI (au) <sup>119</sup>	&	Jenoba Corporation

## 6.3 GNSS Market Trends

### 6.3.1 Consumer Solutions

It has been long time since the most of mobile phones became equipped with embedded GNSS receivers, and consumer solutions are mainly provided by commercial enterprises. However, at governmental level the timeline from its Basic Plan for the Advancement of Utilizing Geospatial Information selects GIS and Indoor Positioning as areas with a major impact on general consumers' benefits. The reason behind this policy push is the fact that consumers cannot fully utilise LBS, even if they have high performance embedded GNSS receivers in their mobile phones, unless sophisticated GIS-based maps are available. In addition, consumers spend more time indoor than outdoor, where GNSS signals are more easily available.<sup>120,121</sup>

<sup>116</sup> <http://qbic.eiseisokui.or.jp/media/pdf/council/International/3-01.pdf>

<sup>117</sup> [https://www.nttdocomo.co.jp/biz/service/highprecision\\_gnss\\_positioning/](https://www.nttdocomo.co.jp/biz/service/highprecision_gnss_positioning/)

<sup>118</sup> <https://www.softbank.jp/biz/iot/service/ichimill/>

<sup>119</sup> <https://news.kddi.com/kddi/corporate/newsrelease/2020/04/24/4399.html>

<sup>120</sup> [https://www.cas.go.jp/jp/seisaku/sokuitiri/290324/170324\\_schedule.pdf](https://www.cas.go.jp/jp/seisaku/sokuitiri/290324/170324_schedule.pdf)

<sup>121</sup> <https://www.mlit.go.jp/kokudokeikaku/gis/gis/img/kihon1.pdf>

### 6.3.1.1 Expediting Social Innovation with GNSS technologies

A small 4-staff start-up named “**SensinGood Lab**” is now developing a **unique wearable device for visually impaired people**.<sup>122</sup> They adopt QZSS’s SLAS (Sub-Meter Level Augmentation Service) as well as footwear as the man-machine interface for the visually impaired users instead of canes. The device is named “**Ashirase**”, combining the Japanese words Ashi + Shiraseru meaning is Foot + Signalling.<sup>123</sup> The idea has been awarded two major domestic prizes: the S-Booster 2019 Grand Prize from the Japanese Government as well as the Social Innovation Award 2019 from Nippon Foundation.<sup>124</sup>

## 6.3.2 Manned Aviation

Japan’s **MSAS (MTSAT Satellite-based Augmentation System)** is **fully compatible with ICAO’s international SBAS standards** and was officially serviced in September 2007. The MSAS signal was originally transmitted via MTSAT-1R at 140E launched in February 2005 and MTSAT-2 at 145E launched February 2006. Although MTSAT stands for “Multi-functional Transport Satellites,” its primary mission are Geostationary Weather Satellites. **Since April 2020, the MSAS signal has been transmitted via the 3<sup>rd</sup> satellite of QZSS at 127E.**<sup>125</sup>

To ensure the global interoperability of aviation standards, the Japan Civil Aviation Bureau (JCAB) of MLIT has been leading Collaborative Actions for Renovation of Air Traffic Systems (CARATS), involving all of Japan’s aviation stakeholders. This effort is **closely coordinated with the SESAR-project** (Single European Sky ATM Research) in Europe and NextGen (Next Generation Air Transportation System) in USA.

Japan features 97 public airports and 4 private airports in total, excluding the military airports of JSDF (Japan Self-Defence Force) and the stationed US Military. **41 of these airports accommodate international flights and have already implemented RNP-AR** (Required Navigation Performance - Authorization Required) approach procedures.<sup>126</sup> The airspace surrounding the 41 airports are equipped with RNP-1 arrival procedures. Most of the routes between airports are **already implemented with RNAV-5**, which is now being deployed to all the routes in Japan.<sup>127</sup>

## 6.3.3 Road Transportation and Automotive

The Japan Electronics and Information Technology Industries Association (JEITA) has released the **Standard Specifications for On-Vehicle Receivers of the Disaster & Crisis Alert directly broadcasted from QZSS via L1S signal**. The Disaster & Crisis Alert of QZSS is one of the measures to promptly convey Japanese Governmental **disaster notifications** such as the disaster prevention

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<sup>122</sup> <https://www.facebook.com/senshigoodlab/>

<sup>123</sup> [https://qzss.go.jp/usage/userreport/ashirase\\_200225.html](https://qzss.go.jp/usage/userreport/ashirase_200225.html)

<sup>124</sup> <https://www.social-innovation.jp/speakers/407/>

<sup>125</sup> [https://qzss.go.jp/overview/services/sv12\\_sbass.html](https://qzss.go.jp/overview/services/sv12_sbass.html)

<sup>126</sup> [https://www.mlit.go.jp/koku/koku\\_fr13\\_000006.html](https://www.mlit.go.jp/koku/koku_fr13_000006.html)

meteorological information released by the Japan Meteorological Agency (JMA) to support **safe and speedy evacuation even in areas where communication networks are weak**, such as mountainous areas, or in situations where communication is interrupted due to damage to ground infrastructure.

As the standard specification has been established, many domestic electronics manufacturers for car navigation systems, dashboard-cameras, etc. are expected **to develop receivers, and then the Disaster & Crisis Alert of QZSS becomes popular**.

The spearhead example of such receivers is the device released by “Cellstar Kogyo,” the **Detector of Radar/Laser/Camera for Speed Limit Enforcement**, which is – contrary to most countries – not illegal in Japan. This kind of detectors are popularly equipped with **GNSS-enabled maps like car-navigation devices** in order to inform the locations of Radar/Laser/Camera to drivers. “Cellstar Kogyo” adopts QZSS’s **SLAS signal transmitted via L1S frequency** in order to improve the positioning accuracy of the vehicle and this L1S receiver can **simultaneously be used to receive Disaster & Crisis Alerts**.<sup>128</sup>

On the other hand, the Road Transport Bureau (RTB) of the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) has been very active with the **promotion of autonomous driving since 2016 when the Autonomous Driving Strategy Headquarter headed by the Minister was launched** in accordance with the consecutive three times of **G7 Transport Ministers Meetings** in Frankfurt in 2015, in Karuizawa in 2016, and Cagliari in 2017, where internationally collaborative promotion and development of automated vehicles were discussed.<sup>129</sup>

In that same year, the RTB **established the “Laboratory of Standardization for Autonomous Driving”** by public-private co-funding as a branch of Japan Automobile Standards Internationalization Center (JASIC).<sup>130</sup>

In 2018, the RTB has established the **Working Group for Demonstration of Autonomous Driving on Public Roads**, as well as the Research Group on Bodily Injuries Liabilities caused by Autonomous Driving.<sup>131</sup> One year later, the RTB revised the **Act for Registration, Inspections, Maintenance, Safety Criteria for Vehicles**, which has been never translated since its original promulgation in 1951, in order to cover recently developed Autonomous Driving vehicles with intention **to promote Level-3 in expressways and Level-4 in the limited areas**.<sup>132</sup>

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<sup>128</sup> <https://www.cellstar.co.jp/products/gps/ar/ar-separate/ar-3.html>

<sup>129</sup> [https://www.mlit.go.jp/jidosha/jidosha\\_tk7\\_000018.html](https://www.mlit.go.jp/jidosha/jidosha_tk7_000018.html)

<sup>130</sup> [https://www.jasic.org/j/14\\_automated-driving/1\\_overview.htm](https://www.jasic.org/j/14_automated-driving/1_overview.htm)

<sup>131</sup> [https://www.mlit.go.jp/jidosha/jidosha\\_tk2\\_000048.html](https://www.mlit.go.jp/jidosha/jidosha_tk2_000048.html)

<sup>132</sup> [https://www.mlit.go.jp/jidosha/jidosha\\_tk2\\_000048.html](https://www.mlit.go.jp/jidosha/jidosha_tk2_000048.html)

### 6.3.4 Drones

In order to promote the utilisation of drones, while minimising adverse impacts of rapidly growing numbers of drones on manned aviation and around airports, the Japan Civil Aviation Bureau (JCAB) has been preparing a series of regulations such as **(1) the registration system of drones, owners, and operation licensees, (2) the no-fly zones around airports, (3) penal rules.** Besides, JCAB has just organized a committee for “**Level-4 BLOS flights over people habitation areas**” to investigate both technical and legal issues with the aim realize such flights in FY 2022 as a Japanese governmental policy.<sup>133</sup>

The domestic drone business market in Japan is estimated to be 140.9 billion yen (EUR 1.18 billion) in FY 2019, up 47.8 billion yen (EUR 400 million) from 93.1 billion yen (EUR 779 million) in FY 2018 (a 51% increase); and is **expected to grow to 19.32 billion yen in FY 2020 (a 37% increase)** and reach 642.7 billion yen (EUR 5.375 billion) in FY 2025 (approximately 4.6 times the 2019 level).<sup>134</sup>

### 6.3.5 Maritime

In order to promote QZSS adoption, the Japan Maritime Bureau (JMB) of MLIT has been active at the International Maritime Organization (IMO). At the NCSR-7 (7th Navigation Safety, Radio Communication and Search & Rescue Subcommittee) held at the IMO Headquarters in London in January 2020, the performance of QZSS has been confirmed, and a draft of the performance standards for the receivers on vessels has been prepared. It is **expected that QZSS will be officially recognized as one of the satellite navigation systems for vessels** and widely used internationally after further verification.<sup>135</sup>

Prior to the epoch above, Japan Coast Guard under MLIT has already **terminated their Differential GPS services** transmitted over 309 kHz from 27 coastal radio stations in March 2019.<sup>136</sup> Because (1) the **positioning accuracy of GPS itself has drastically improved to 10m** from the original 100m in the past and satisfying the specifications of IMO without any augmentation; (2) MLIT is operating MSAS broadcasted from geostationary weather satellite as one of the regional SBAS system; (3) **QZSS can provide a much better accuracy of 1 m.**

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<sup>133</sup> [https://www.mlit.go.jp/report/press/kouku02\\_hh\\_000154.html](https://www.mlit.go.jp/report/press/kouku02_hh_000154.html)

<sup>134</sup> <https://research.impress.co.jp/report/list/drone/500869>

<sup>135</sup> [https://www.mlit.go.jp/report/press/kaiji06\\_hh\\_000214.html](https://www.mlit.go.jp/report/press/kaiji06_hh_000214.html)

<sup>136</sup> <https://www.kaiho.mlit.go.jp/soshiki/koutsuu/dgps/haishi.pdf>



### 6.3.6 Emergency Response

The Fire and Disaster Management Agency (FDMA) under the Ministry of Internal Affairs and Communications (MIC) in 2007 deployed a countrywide system to automatically locate and identify emergency calls. Simultaneously, MIC has issued an administrative direction to all mobile carriers to mandatorily implement 3G-equipped or newer phones with an **Automatic GNSS/Cell-ID Location Notifier associated with Emergency Calls** to the police #110, to Japan Coast Guard #118, and to the fire department #119.<sup>137</sup> This is also valid for land-line carriers which are required to implement a similar notifier of caller's registered address and the name.

On the other hand, the Road Transport Bureau (RTB) of Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) has partially revised **the Public Notice of the Details of Safety Standards for Road Vehicles** in 2018 in order to start the implementation of **automatic road-accident emergency call devices** that automatically **reports the location of vehicle accidents** in accordance with international standards developed at the World Forum for Harmonization of Automotive Standards (WP29) of the United Nations Economic Commission for Europe.<sup>138</sup> It has been mandatory to apply **since 1 January 2020** for new models and **from 1 July 2021** for continuous production models. This domestic standards in Japan is **compatible with European standards for "eCall"** and subject to UN Mutual Recognition Agreement of Type Approval of Vehicles.

In parallel with this legislation about the in-vehicle electronics, automotive companies such as automotive manufacturers, car electronics manufacturers, insurance companies, major mobile communications carriers, etc. have co-funded a call centre provider named "Japan Mayday Service Co., LTD" aka "**HelpNet**" in 1999.<sup>139</sup> HelpNet is more than just a call centre, it uses the GNSS location data of the accident and provides the information directly to the 52 police headquarters and 70% of the fire departments command centres countrywide.

### 6.3.7 Rail

Japan's railway systems do not utilise GNSS as of yet, although there **have been several experiments applying GNSS on real railways in Japan for many years**. As the railway sector in Japan must maintain high safety standards under difficulties such as the ageing of railway infrastructure as well as a shortage of next generation train drivers, maintenance workers, and other railroad personnel, both labour-saving and work-streamlining are pressing issues. This context is an excellent use case for GNSS as a key technology to revolutionise railways.

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<sup>137</sup> [https://www.soumu.go.jp/menu\\_seisaku/ictseisaku/net\\_anzen/hijyo/tuho.html](https://www.soumu.go.jp/menu_seisaku/ictseisaku/net_anzen/hijyo/tuho.html)

<sup>138</sup> [https://www.mlit.go.jp/report/press/jidosha07\\_hh\\_000277.html](https://www.mlit.go.jp/report/press/jidosha07_hh_000277.html)

<sup>139</sup> [https://www.helpnet.co.jp/company/download/pdf/com\\_prof\\_en.pdf](https://www.helpnet.co.jp/company/download/pdf/com_prof_en.pdf)

Particular attention to this is paid by the Japan Railway Bureau of MLIT, which has **officially started to consider utilising GNSS for Japanese railway systems** and organised an experts committee in February 2019 shortly after the start of operations of the 4-satellite QZSS constellation in November 2018.

The committee's major concerns relate to safety i.e. prevention of accidents. Therefore, the committee assumes that **applying GNSS to train-control is too early until fail-safe systems with GNSS appropriate for train operations and the procedures of re-acquisition of GNSS signals after passing through mountain tunnels becomes established**.<sup>140</sup> However, the committee in question has become well aware of the conveniences brought by GNSS and suggested to start applying GNSS from non-crucial usages in areas with good GNSS coverage.

### 6.3.8 Agriculture

Agriculture in Japan has been facing a severe shortage of labour force due to an aging population. The sector currently focuses on the use of automation, machinery and the succession of various cultivation skills and know-how to a next generation of farmers.

Against this context, the Japan Agricultural Production Bureau (JAPB) of Ministry of Agriculture, Forestry and Fisheries (MAFF) **organized the "Task Force for Realization of Smart Agriculture"** in November 2013 with the cooperation of leading companies in advanced technologies such as robots, IoT, satellites, etc. with the aim to **realise Japan's smart agriculture including drones and autonomous unmanned tractors**.<sup>141</sup>

The Task Force has published an Interim Report in March 2014 including (1) the future vision of smart agriculture: a **new agricultural landscape with robot technology and ICT**, (2) a roadmap, and (3) points to be considered in these actions.<sup>142</sup>

A second **"Safety Assurance Guideline for Automatic Running Agricultural Machinery"** was issued in March 2017, and revised twice in 2018 and 2020 in accordance with the evolutions of the technologies. This guideline **stipulates the mandatory conditions for manufacturers, purchasers, and the actual operators to ensure the safety of robotic farm machineries to run automatically by utilising GNSS under supervision from inside or around the fields**.<sup>143</sup>

Since then, JAPB of MAFF has **shifted their concentration to the promotion and demonstrative pilot projects of robotic farm machineries as well as public funding to R&D in private agricultural sectors**.<sup>144,145</sup>

<sup>140</sup> [https://www.mlit.go.jp/tetudo/tetudo\\_tk7\\_000014.html](https://www.mlit.go.jp/tetudo/tetudo_tk7_000014.html)

<sup>141</sup> [https://www.maff.go.jp/j/kanbo/kihyo03/gityo/g\\_smart\\_nougyo/index.html](https://www.maff.go.jp/j/kanbo/kihyo03/gityo/g_smart_nougyo/index.html)

<sup>142</sup> [https://www.maff.go.jp/j/kanbo/kihyo03/gityo/g\\_smart\\_nougyo/pdf/cmatome.pdf](https://www.maff.go.jp/j/kanbo/kihyo03/gityo/g_smart_nougyo/pdf/cmatome.pdf)

<sup>143</sup> <https://www.maff.go.jp/j/kanbo/smart/attach/pdf/index-80.pdf>

<sup>144</sup> <https://www.maff.go.jp/j/kanbo/smart/181121.html>

<sup>145</sup> [https://www.maff.go.jp/j/kanbo/smart/2020\\_sma\\_yoko.html](https://www.maff.go.jp/j/kanbo/smart/2020_sma_yoko.html)

### 6.3.9 Geomatics

In the wake of the Great Hanshin-Awaji Earthquake in January 1995, Geographical Information Systems (GIS) were widely used by the relevant ministries and agencies to assess the disaster situation and formulate reconstruction plans. However, **these ministries and agencies developed their own systems and data individually, limiting efficiencies**. Based on this lesson, in September of the same year, the Cabinet established the **Liaison Council of Ministries and Agencies Related to Geographic Information Systems** (now defunct) to take the necessary measures for the spread of GIS.

On the other hand, in the area of satellite positioning, as the Global Positioning System (GPS) serviced by the United States has been able to provide **10 times more accurate position than before since May 2000** due to termination of Selective Availability (SA), the use of GPS in surveying has expanded widely. Besides, in 2002, Japanese government has **switched the datum to the World Geodetic System**. As the convenient result, the positional coordinates indicated by GPS and the coordinate values indicated by the domestic map were the same (until then, it was necessary to convert the coordinate values by calculation, etc., because the standards were different). Eventually, **the use of GIS and satellite positioning saw a drastic increase**.<sup>146</sup>

Nowadays, the National Spatial Planning & Regional Policy Bureau of Ministry of Land, Infrastructure, Transportation & Tourism has been in charge of the promotion and uptake of geospatial information based on a domestic law named **Basic Act on the Advancement of Utilizing Geospatial Information promulgated in 2007**. The Bureau has issued and periodically updated the **Basic Plan for the Advancement of Utilizing Geospatial Information** in 2008 for the 1<sup>st</sup> term, in 2012 for the 2<sup>nd</sup> term, and in 2017 for the 3<sup>rd</sup> term.

This Basic Act aims to comprehensively and systematically promote measures for the promotion of the utilisation of geospatial information by **clarifying the responsibilities of the national government and local governments** as well as by setting forth the basic principles of geospatial information adoption measures.<sup>147,148</sup>

In order to maintain the Basic Plan, the **Geospatial Information Utilization Advancement Council** was established in 2008 with representatives from industry, academia and government, and its secretariat named the **Geospatial Information Utilization Advancement Office** was also established simultaneously in the Cabinet Secretariat.<sup>149</sup>

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<sup>146</sup> [https://www.gsi.go.jp/chirikukan/about\\_kihonhou.html](https://www.gsi.go.jp/chirikukan/about_kihonhou.html)

<sup>147</sup> [https://www.mlit.go.jp/kokudoseisaku/kokudoseisaku\\_tk1\\_000039.html](https://www.mlit.go.jp/kokudoseisaku/kokudoseisaku_tk1_000039.html)

<sup>148</sup> <https://www.gsi.go.jp/kokusaikoryu/kokusaikoryu-e30004.html>

<sup>149</sup> <http://www.cas.go.jp/jp/seisaku/sokuitiri/index.html>

### 6.3.10 Critical Infrastructures

After long historical transitions, the National Institute of Information and Communications Technology (NICT) under the Ministry of Internal Affairs and Communications (MIC) is currently in charge of maintaining both **Time Standard of Japan and Frequency Standard of Japan**.

NICT has already developed and successfully demonstrated the world first next generation<sup>37</sup> Strontium Optical Lattice Clock in 2018, **which is more accurate and more precise than the world's standard time** named “Coordinated Universal Time” that is maintained by Bureau International des Poids et Mesures (BIPM) near Paris using Cesium Atomic Clocks, with which the similar Cesium Atomic Clocks currently used for maintaining Standard Time of Japan at NICT has been compared and synchronized since 1983 by using GPS.<sup>150</sup>

NICT has been **propagating this Standard Time of Japan to all over Japan by transmitting the Standard Frequency** from the two stations which opened in 1999 and 2001 respectively, as well as by publicizing via internet the NTP Server (ntp.nict.jp) directly connected to the Cesium Atomic Clocks since 2006.<sup>151</sup>

On the other hand, Japan’s high-end **commercial GNSS timing market**, serving areas such as finance, broadcasting, satellite communications, data centres, etc. **is dominated by “SEIKO Solutions”** one of the subsidiaries of the oldest clock manufacturer in Japan: “SEIKO Watch,” which developed and released the world first GPS solar watch. **SEIKO Solutions has product lines ready for Galileo with the Precision Time Protocol (PTP) interface required to comply EU’s Markets in Financial Instruments Directive - 2 (MiFID-2)**.<sup>152</sup>

According to the annual market report *Mobile Phone Base Station Market and Peripheral Components Market Present and Future Forecast 2019* issued by MCA Inc. in Japan, as for the **much larger market of GNSS Time Servers**, the **cellular base stations seem to be dominated by Northern European vendors such as Nokia and Ericson as well as Asian vendors such as Samsung, Huawei, ZTE; and the domestic vendors such as NEC and Fujitsu are losing their market share**.<sup>153</sup>

<sup>150</sup> <https://www.nict.go.jp/press/2018/03/15-1.html#%E8%AB%96%E6%96%87>

<sup>151</sup> <http://www2.nict.go.jp/sts/jst/index-e.html>

<sup>152</sup> [https://www.seiko-sol.co.jp/en/products/time\\_server/](https://www.seiko-sol.co.jp/en/products/time_server/)

<sup>153</sup> <https://k-tai.watch.impress.co.jp/docs/column/mca/1211311.html>

## 6.4 Macro Technology Trends

### 6.4.1 Robotics

The recent governmental policies related to robotics has been re-initiated in 2014 by the Keynote Speech “**New Industrial Revolution with Robots**” of the Prime Minister at the OECD Ministerial Council, followed by the establishment of the **Committee for Realization of Robot Revolution** in 2016 to publicize the **New Strategies for Robotics** in 2017, based on which the **Robot Revolution Initiative Council** as the organization to propel the revolution has been established among industries, government, and academia in 2017.<sup>154</sup>

The **Robot Policy Office** of the Manufacturing Industries Bureau of the Ministry of Economy, Trade, and Industry (METI) is leading of the coordination of the policies among Ministries by hosting the **Council for Advancement of Social Innovation through Robots** consists of the Cabinet Office (CAO), the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Health, Labour and Welfare (MHLW), and METI since May 2019.<sup>155</sup>

The Robot Policy Office is conducting its own promotion of robots in industries, such as R&D of nursing-care robots for the rapidly ageing society of Japan, the incubation of Robot System Integrators (Robot Sler), the construction of **Fukushima Robot Test Field**, the convening of the **World Robot Summit/Competition 2020**, to be postponed to 2021 due to Covid-19.<sup>156</sup>

### 6.4.2 Big Data

The 1<sup>st</sup> “**Japan Revitalization Strategy**” as the governmental economic growth policy has been approved by the Cabinet in June 2013, and revised every year thereafter. In the “Japan Revitalization Strategy 2016,” the new concept named “**Society 5.0**,” which is analogy of Industry 4.0 in Germany, was publicized as the ideal state for Japan to aim for.

In the Society 5.0, **all people and objects are connected via IoT, various knowledge and information are shared, and new values are created through inter-disciplinary collaboration**; AI will enable easier information delivery when and what needed, and technology such as robots and autonomous vehicles will enable us to overcome challenges such as low birth rate and ageing populations, depopulation in rural areas, and disparities between the rich and poor. In the **Society 5.0**, vast amounts of information i.e. **Big Data from sensors in physical space** will be accumulated in cyberspace and is **analysed by AI** instead of human; and the results are fed back to humans in physical space in a variety of ways, in order to bring new values to industry and society that has not been possible before.<sup>157</sup>

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<sup>154</sup> <https://www.jmfrri.gr.jp/english/>

<sup>155</sup> [https://www.meti.go.jp/shingikai/mono\\_info\\_service/robot\\_shakaihenkaku/index.html](https://www.meti.go.jp/shingikai/mono_info_service/robot_shakaihenkaku/index.html)

<sup>156</sup> [https://www.meti.go.jp/policy/mono\\_info\\_service/mono/robot/index.html](https://www.meti.go.jp/policy/mono_info_service/mono/robot/index.html)

<sup>157</sup> [https://www8.cao.go.jp/cstp/society5\\_0/](https://www8.cao.go.jp/cstp/society5_0/)

As an important key step to realize this Society 5.0, the **"Basic Act for Advancement of Utilization of Public-Private Data"** has also parallelly been enacted in 2016. This act explicitly obliges both national and local governments to take initiative for **"Open Data"** in order to help solve problems, revitalize the economy, and improve the sophistication and efficiency of government through the promotion of public participation and public-private cooperation.<sup>158</sup>

On the other hand, in order to utilize vast amount of personal information accumulated in private sectors as big data, the **Act of the Protection of Personal Information** originally established in 2003 has been drastically revised twice in 2015 and 2020. In 2015, **"Anonymously Processed Information,"** by which personal information cannot be recovered, has become allowed to be provided to third parties. In 2020, **"Pseudonym Processed Information,"** by which individuals cannot be identifiable due to deleted names, has been introduced to skip processes of consent in case of internal usage.

### 6.4.3 Digitalisation and AI

The Cabinet has established the **Council for Advancement of the Integrated Innovation Strategy** in accordance with the **"Integrated Innovation Strategy"** approved by the Cabinet in June 2018.<sup>159</sup> This Council promotes the Strategy by inter-disciplinarily coordinating policies among the innovation relevant commanding councils such as the Council for Science, Technology, and Innovation, the Strategic Headquarters for the Promotion of an Advanced Information and Communications Network Society, the Intellectual Property Strategy Headquarters, the Headquarters for Health and Medical Strategy, the Strategic Headquarters for Space Development, the Headquarters for Ocean Policy, the Council for Advancement of Utilization of Geospatial Information,

AI is one of the major categories to be advanced by the Integrated Innovation Strategy; and the Council has published the **"AI Strategy 2019"** in June 2019 as well as organized a sub-council named **"AI Steering Committee"** in order to implement action plans to achieve goals listed in the Strategy.<sup>160</sup> This Strategy was announced at the G20 in Osaka in June 2019 as well.

The Strategy adopts **3 philosophies and 7 principles** similar to the ones in the **EU's Ethics Guidelines for Trustworthy AI**. The 3 philosophies are Dignity, Diversity & Inclusion, and Sustainability. The 7 principles are People Oriented, Privacy, Security, Innovation, Education & Literacy, Fairness, and Accountability & Transparency. Besides, there are **4 Strategic Objectives** such as Human Resource Development, Strengthening Industrial Competitiveness, Establishment of System of Technologies, and Internationalization.

Although one project related to **Autonomous Driving** is included among examples of projects that are financed by the Government in accordance with the Strategy, the most popular application

<sup>158</sup> <https://cio.go.jp/policy-opendata>

<sup>159</sup> <https://www.kantei.go.jp/jp/singi/tougou-innovation/>

<sup>160</sup> [https://www.kantei.go.jp/jp/singi/ai\\_senryaku/pdf/aistrategy2019en.pdf](https://www.kantei.go.jp/jp/singi/ai_senryaku/pdf/aistrategy2019en.pdf)



of recently booming deep-learning seems to be **Rapid Image Recognition/Analysis** such as the remote diagnosis system of Covid-19 pneumonia, the video measurement system for size & weight of tuna fish swimming in raising preserve, as well as **Embedded Control of Things** for household appliances and industrial electric equipment similar to the **Neuro-Fuzzy** boomed in the 1990's just after the 2<sup>nd</sup> boom of AI.

#### 6.4.4 Climate Change

Following the adoption of the Kyoto Protocol at the 3rd Conference of the Parties (COP3) to the United Nations Framework Convention on Climate Change (UNFCCC) held in Kyoto in 1997, Japanese Government as the President of the COP3 has legislated the “**Act on Promotion of Global Warming Countermeasures**” for the national government, local governments, business operators, and citizens to work together as the **first step in Japan's global warming countermeasures** – the world's first law aimed at preventing global warming.<sup>161</sup>

Subsequently, the **Headquarters for the Promotion of Global Warming Countermeasures** was established directly under the Cabinet, and the **Earth Warming Countermeasures Division** was also established under the Earth Environment Bureau of Ministry of the Environment (MoE). The Headquarters established **the Guideline for Promotion of Global Warming Countermeasures** in 2002, and the Division established **the Plan for Global Warming Countermeasures** in 2016.<sup>162</sup> The Act has also been revised 5 times until now. The guideline is recommending some indirect measures in the category of transportation, such as **traffic flow optimization and eco-driving, to which GNSS technologies are applicable**, in addition to much more direct measures such as EV or FCV.

On the other hands, more direct contribution of GNSS technology to the Climate, since October 2009 **Japan Meteorological Agency (JMA) has been adopting the ground GNSS precipitation** data that is calculated from the data observed at 1300 Continuously Operating Reference Stations (CORS) throughout Japan maintained by the Geospatial Information Authority of Japan (GSI) in the meso analysis to create the initial value of the Meso-Numerical Forecast Model (MSM) in order to improve the accuracy of the **initial value of water vapor and improve the accuracy of precipitation predictions**.<sup>163</sup> In other words, **GNSS precipitation data has already been used for the official weather forecast on a daily basis for more than 10 years**. Both JMA and GSI are under the Ministry of Land, Infrastructure, Transportation, and Tourism (MLIT).

#### 6.4.5 Silver Economy

Japanese government has established a domestic law named “**The Basic Law on Measures for the Aging Society**” in 1995 in order to cope with the world fastest aging society in Japan.<sup>164</sup> This Law

<sup>161</sup> <http://www.env.go.jp/earth/ondanka/ondanhou.html>

<sup>162</sup> [https://www.env.go.jp/earth/ondanka/keikaku/tikyuondankataisakukeikaku\\_gaiyou.pdf](https://www.env.go.jp/earth/ondanka/keikaku/tikyuondankataisakukeikaku_gaiyou.pdf)

<sup>163</sup> [http://www.jma.go.jp/jma/press/0910/27a/MSM\\_GPS.pdf](http://www.jma.go.jp/jma/press/0910/27a/MSM_GPS.pdf)

<sup>164</sup> <https://www8.cao.go.jp/kourei/index.html>



assigns **the Cabinet Office (CAO)** to be in charge of planning, drafting, and coordinating policies for the aging society, and relevant ministries and agencies implement wide variety of measures.

The CAO serves for the supreme decision-making body for measures for the ageing society named **“the Council on Measures for the Aging Society** (Chairman: the Prime Minister),” which prepares and updates **“the Guideline of Measures for the Ageing Society”** as well as the annual **“White Paper on Aging Society”** to be reported to the Diet.<sup>165</sup>

The first Guideline was approved by the Cabinet in 1996, then updated twice, and the **latest Guideline** has been effective since 2018.<sup>166</sup> The current Guideline **recommends utilization and promotion of advanced technology such as nursing-care robots, unmanned autonomous driving transportation systems, and genome science** in order to vitalize the market for elders in addition to other socio-medical measures.

The current Guideline is associated with the list of quantitative goals to be targeted. For example, unmanned autonomous driving transportation systems with SAE Level-4 to be deployed all over Japan by 2025, the **market size of nursing-care robot** should be 50 billion yen (EUR 418 million) in 2020, which seems half achieved.<sup>167</sup>

## 6.4.6 Cyber Security

In February 2000, with the rapid expansion of the use of the Internet and other advances in IT in Japanese society and people's daily lives, the **Information Security Promotion Office** was established in the Cabinet Secretariat in order to plan, formulate, and comprehensively coordinate the promotion of information security measures in the public and private sectors, in response to a growing sense of crisis regarding information security issues such as the occurrence of unauthorized access cases and the spread of computer viruses.

In April 2005, the Information Security Promotion Office was strengthened and developed, and the **Information Security Center (NISC)** was established in the Cabinet Secretariat in accordance with the "Review of the Role and Functions of the Government to Address Information Security Issues" (decided by the IT Strategy Headquarters on December 7, 2004). This Center also acted as the secretariat of the **Information Security Policy Council**, which was established under the IT Strategy Headquarters at the same time.

In November 2014, the **Basic Act on Cyber Security** was enacted. In January 2015, in accordance with the Act, the **Cyber Security Strategy Headquarters** was established in the Cabinet and the Information Security Center was reorganized and the **National center of Incident readiness and Strategy for Cybersecurity (NISC)** was established in the Cabinet Secretariat in accordance with the Cabinet Secretariat Organization Ordinance.

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<sup>165</sup> <https://www8.cao.go.jp/kourei/whitepaper/index-w.html>

<sup>166</sup> <https://www8.cao.go.jp/kourei/measure/taikou/index.html>

<sup>167</sup> [https://www8.cao.go.jp/kourei/measure/taikou/pdf/p\\_suuchi.pdf](https://www8.cao.go.jp/kourei/measure/taikou/pdf/p_suuchi.pdf)

**NISC coordinates** cybersecurity policy by formulating of Cybersecurity Strategy, of Cybersecurity Policy for Critical Infrastructure Protection, of Common Standard on Information Security Measures of Government Entities, of Cybersecurity Human Resource Development Plan, and of Cybersecurity Research and Development Strategy etc.<sup>168</sup>

As an example of coordination and promotion by NISC, the Ministry of Internal Affairs and Communications (MIC) and Ministry of Economy, Trade and Industries (METI) have **co-implemented a preferential corporate tax treatment** named **“Connected Industries (IoT) Taxation”** with limited term between FY2018 and FY2019 for enterprises who improve productivity by **adopting IoT sensors, robots, data collection systems, etc. implemented with some extent of cybersecurity measures.**<sup>169</sup>

On the other hand, the Japanese GNSS constellation named “Michibiki” aka “QZSS: Quasi-Zenith Satellite System” also might have some sort of authentication function, currently under governmental procurement process, at the timing of **deployment of additional 3 satellites into space in order to complete the transformation from the current 4-satellite configuration to the final 7-satellite constellation in 2023.**

## 6.4.7 Sharing Economy

The "Sharing Economy Promotion Office" established in January 2019 within the Information and Communication Technology (IT) Strategy Office of the Cabinet Secretariat in response to the interim **“Sharing Economy Promotion Program”** compiled by the Sharing Economy Exploration Council established in November 2018 under the leadership of the Director-General of the IT Strategy Office of the Cabinet Secretariat (CIO of the government of Japan) is **now coordinating the Japanese governmental policies in order to promote sharing economy in Japan.**

In addition to functioning as a point of contact for information and consultation, this **Sharing Economy Promotion Office** promotes the dissemination and promotion of voluntary rules, liaison and coordination with relevant ministries and agencies, etc., **introduction of best practices, and other efforts to promote the sharing economy.**<sup>170</sup> The Office will announce the progress of the project once a year. Based on the progress of the service, review measures, including model guidelines, as appropriate and steadily promote them.

The Exploration Council has **published a Reference of Sharing Economy Guideline** to be adopted and followed by matching-platformers. The purpose of this Guideline is to ensure safety and reliability of the services provided by matching-platformers by clarifying responsibilities of the platformers, providers, and users respectively.

In order to **improve public awareness** of Sharing Economy and to propagate the Guideline, major players in the sharing economy sector established an NGO named “Sharing Economy Association

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<sup>168</sup> <https://www.nisc.go.jp/eng/index.html#sec1>

<sup>169</sup> [https://www.soumu.go.jp/main\\_content/000603219.pdf](https://www.soumu.go.jp/main_content/000603219.pdf)

<sup>170</sup> <https://cio.go.jp/share-eco-center/>

Japan," which is now **issuing the certifications to the matching-platformers whose business practices comply the Reference of Guideline.**<sup>171</sup>

In parallel with the activities above among private sectors, Ministry of Internal Affairs and Communications (MIC), which is in charge of coordination between the Japanese central Government and local municipality governments, **is supporting the efforts of local governments to solve local issues and revitalize local economies by applying the "Sharing Economy" approaches to idle assets such as vacant houses and individuals who has special skills and/or knowledge.**<sup>172</sup>

At the same time as the Promotion Office established, in January 2019, **ISO has established a new technical committee to establish an international standard** for the "sharing economy" based on the proposal from Japan. The first international conference was convened in Japan in June 2019 trying to deploy Japanese model as an international standard.

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<sup>171</sup> [http://www.kantei.go.jp/jp/singi/it2/senmon\\_bunka/shiearingu/dai2ji-gaiyou.pdf](http://www.kantei.go.jp/jp/singi/it2/senmon_bunka/shiearingu/dai2ji-gaiyou.pdf)

<sup>172</sup> [https://www.soumu.go.jp/main\\_sosiki/jichi\\_gyousei/c-gyousei/sharing\\_economy.html](https://www.soumu.go.jp/main_sosiki/jichi_gyousei/c-gyousei/sharing_economy.html)

# 7 Australasia

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## 7.1 Introduction

Australasia is home to several countries that are rapidly developing their space industries, with major new developments being seen after **countries in the region having partnered with the more mature space industries** across Europe, the United States, and Asia.

One of the key players in this region is Australia who **are rapidly investing in the space industry** in the region, with Queensland, Australia investing AUS\$8 million (EUR 4.9 million) into the region under the **Queensland Space Industry Strategy 2020-2025 program** where they are looking to **leverage technologies including GNSS to foster innovation** to allow them to stay world leaders in industries such as mining, land management, and agriculture.<sup>173</sup>

Alongside funds, Australia is **paving the way forward for EU-Australia collaboration** in the space industry as shown with the **development of the regional Copernicus hub** in collaboration with ESA. This is further supported by the **opening of their Australian Space Agency headquarters** in Adelaide this February which should further improve the capacities of the country.<sup>174</sup>

Strong bilateral relations between Malaysia and Japan were seen in 2020, with Yoshikazu Shoji, JAXA's director of the international relations and research department highlighting the strong experience that Malaysia has with satellites and **their goals of sending another human to space by 2030**. This shows both the strengths and the opportunities of the country. Japan is also coordinating with Thailand with a study in Chumphon, Thailand where they will be **investigating how plasma bubbles cause radio interference** impacting GNSS systems around the equator.

Asian cooperation is not only seen with Malaysia and Thailand, with **Japan looking to cooperate and strengthen the space industry in countries such as Vietnam and the Philippines**.<sup>175</sup>

All across the region, the achievements of GNSS technologies have received international attention with the Australian bushfires making the news at the start of the quarter, and the COVID-19 pandemic pushing innovation in the industry towards the end of the quarter.

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<sup>173</sup> <https://www.statedevelopment.qld.gov.au/resources/strategy/space-industry-strategy-2020-25.pdf>

<sup>174</sup> <https://www.industry.gov.au/news-media/australian-space-agency-news/australian-space-agency-opens-in-adelaide>

<sup>175</sup> <https://spacewatch.global/2020/02/japan-eyes-space-cooperation-with-malaysia-as-balance-to-chinese-influence-in-se-asia/>

Segment		Key Trends
Upstream		Australian launch <b>delayed due to COVID-19</b> . A <b>high accuracy SBAS system</b> is being developed by Australia and New Zealand, providing an <b>accuracy of ten centimetres by 2023</b>
Market Trends	Drones	Thai 'drone licence' and <b>state of the art training course announced</b> .
	Emergency Response	GNSS used to <b>fight Australian bushfires</b> .
	Agriculture	Low power IoT firm expanded satellites coverage, <b>providing additional support for farmers in rural Australia</b> .
Macro Technology Trends	Geomatics	Australasian firms raised capital to <b>develop the Internet of Places</b> and 3D mapping. First stage of the <b>Punggol Digital District</b> launched.
	Robotics	<b>Joint Australian-NASA robotics centre</b> opened in Perth. Semi-autonomous robots used in the <b>fight against corona in Singapore</b> .
	Climate Change	Air New Zealand joins <b>NASA CYGNSS</b> .

## 7.2 Upstream Developments

### 7.2.1 M2 Pathfinder Launch Delayed due to COVID-19

An Australian satellite launch designed to be a testbed for UAV's and Maritime patrol aircraft was initially due to launch in Q1 of this year. Unfortunately, due to COVID-19 the mission '*Don't Stop Me Now*', was postponed until Q2. The M2 **Pathfinder** is **designed with GNSS capabilities in mind**, with the future plans being to provide the ASA with the **capability to further develop their related industries**.<sup>176</sup> The short delay to Q2 is unfortunate, but understandable given the current climate and short duration of the delay highlights how essential these developments are to the region.

### 7.2.2 Australia-New Zealand Partner to Deploy SBAS by 2023

New Zealand and Australia announced their plans to **deploy a satellite-based augmentation system (SBAS)** to **improve the accuracy** of GNSS signals in the region from **ten metres to ten centimetres**.<sup>177</sup> This is a joint project between **Geoscience Australia** and **Land Information New Zealand** and was announced following the success of cross-industry trial projects. This is part of a larger investment into the region and could **encourage further adoption of high precision GNSS technology in the downstream market segments**.

<sup>176</sup> <https://spacewatch.global/2018/12/australian-military-space-raaf-preparing-m1-and-m2-satellite-demonstration-missions/>

<sup>177</sup> <https://www.gpsworld.com/australia-new-zealand-commit-to-develop-sbas-by-2023/>

## 7.3 GNSS Market Trends

### 7.3.1 Drones

#### 7.3.1.1 Thai *Drone Licence* Announced for Commercial Drone Operators.

Increased regulations is a growing theme in the commercial drone industry, with new developments being seen in Thailand this quarter, with the Civil Aviation Authority of Thailand (CAAT) **announcing their plans to increase regulations in the industry** through the introduction of **mandatory 'drone licences'** obtained after completing training and an exam at an accredited institution.<sup>178</sup> Although this development does increase the barrier to entry, it is beneficial as the **alignment with the international standards will provide greater opportunities to develop the growing commercial drone industry.**

This state of the art training should reduce the likelihood of inexperienced drone users causing aircraft accidents, which was **highlighted as one of the major threats to drone adoption** in Thailand at the **'Drones for Business'** event held in Bangkok in 2018.<sup>179</sup> If the regulations in Thailand continue to trend towards the international standards, we should see the introduction of an Unmanned Traffic Management (UTM) system which **utilises GNSS capabilities to open up the Thai skies to more commercial ventures.**

### 7.3.2 Emergency Response

#### 7.3.2.1 GNSS used in the Fight Against Kangaroo Island Bushfires

South Australian mapping companies leveraged the **real-time located capabilities provided by GNSS technologies** in the fight against the Australian bushfires this January.<sup>180</sup> FireFlight combined the high precision data provided by GPS with thermal cameras mounted to create **a low-cost system to provide both real-time and post-flight data** which is analysed to determine hotspots. FireFlight is also an example of how governments can help foster progress in the industry, as the company **benefited from support from the Venture Catalyst Space program** which is funded by the Space Innovation Fund, a state-funded program aimed to create a globally competitive space sector in Australia.

The **Venture Catalyst Space** program that FireFlight has benefited from opened for applicants in this quarter, with further details of the program being found on their website.<sup>181</sup>

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<sup>178</sup> <https://www.bangkokpost.com/thailand/general/1837244/commercial-drone-flyers-need-to-have-licences-from-this-year>

<sup>179</sup> <https://fling.asia/2019/01/11/thailands-leading-drone-businesses-discuss-the-future/>

<sup>180</sup> <https://icc.unisa.edu.au/newsroom/2020/Home-grown-aerial-mapping-and-intelligence-system-provides-crucial-support-to-fire-recovery-on-Kangaroo-Island/>

<sup>181</sup> <https://icc.unisa.edu.au/programs/venture-catalyst/>

## 7.3.3 Agriculture

### 7.3.3.1 Expansion of Myriota, an IoT Market Leader Delivering Farming Solutions in Australia

Growth was seen in Australia with the expansion of Myriota, **a leader in the innovative IoT connectivity market**. Q1 featured the creation of a North American subsidiary to allow for 24/7 operation of their nanosatellites, with further 25 further satellite launches throughout the year whilst the company aims to **increase revenue under the new Chief Revenue Officer** Barbara Swanson, formerly the VP, Sales and Marketing Director for Asia-Pacific at TeamViewer. A particular focus of the company is in future farming, where they are aiming to solve the problem faced by farmers in rural Australia who are often **unable to access other internet enabled agricultural solutions**.

These developments by Myriota **showcase the power of GNSS based technology**, especially when considering the company's **experience of using low-power IoT solutions** in their partnership with GoannaAg where they successfully delivered improvements in on-farm efficiencies through soil, water, weather, and inventory management.

## 7.3.4 Geomatics

### 7.3.4.1 Singaporean Start-Up Raises US\$2 Million to Create the 'Internet of Places'.

UNL, an originally Dutch, now Singaporean start-up achieved **US\$2 million (EUR 1.78 million) in funding** in Q1 2020 to **leverage GNSS technology to create the 'Internet of Places'**, an answer to the problems created by legacy address systems throughout the world.<sup>182,183</sup> UNL aim to 'unlock the digital economy' **assigning every location an ID** in order to provide accurate addresses for everyone. UNL intend to develop this further by adding smart layers to bring innovation to the world of deliveries and enable other smart city technology. The capital will be used to develop UNL's core infrastructure, and **to expand in Asia and globally**. Local teams are being developed in Singapore, Indonesia, India and Japan. The funding is co-led by Here Technologies and VC fund Elev8.

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<sup>182</sup> <https://www.unl.global/#products>

<sup>183</sup> <https://www.geospatialworld.net/news/singapore-based-unl-raises-2m-to-create-smart-addresses/>



#### 7.3.4.2 Australian Aerometrex Raised AUS \$25 million

It is not just Singapore with upcoming Geomatics based companies, an example from **Australia is Aerometrex**, who raised AU \$25 million (EUR 15.4 million) to introduce a 3D element in the mapping space, allowing for vertical space to be included with the use of **aerial photography** and location models.<sup>184,185</sup> This is a **great showcase of the applications of the more accurate location technology on the market today**, with cross-industry uses including property development, urban planning, insurance, and even disaster management.

#### 7.3.4.3 Drones, GIS, Smart Cities, Big Data, and Mixed Use Development comes together in the stage of the Punggol Digital District.

The first phase of the **Punggol Digital District (Singapore)** – the real-time data platform, was completed this January and will be **acting as a base for the ongoing digital platform development**.<sup>186</sup> Both construction of the project, and the use of the district after completion showcase a range of innovative technologies, with **GIS and aerial scans** by drones being used during the construction phases to **ensure that the construction matches the planned design**.<sup>187</sup> Once the construction is completed the area is intended to be an example of what a smart city can achieve, with everything from building occupancy, to rainfall, through to energy generation. This district shows **how GNSS technology can be combined with other global trends in the cities of the future**, and how it can solve the problems faced in the construction industry where the final builds often don't match up with the original plans.

## 7.4 Macro Technology Trends

### 7.4.1 Robotics

**Australia is set to become a global hub** for robotics and automation with the launch of the industry led consortium **Australian Remote Operations for Space and Earth (AROSE)**, which aims to unify the space and remote operations sector.<sup>188,189</sup> AROSE is not only focused on robotics, but it **comprises of all remote connection technology including autonomous trucks** on mine sites, maritime applications, and even managing life support equipment on Mars. AROSE benefits from members having expertise from multiple industries who have proven experience in remote operations.

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<sup>184</sup> <https://www.geospatialworld.net/news/aerometrex-soars-higher-with-new-3d-models/>

<sup>185</sup> <https://www.architectureanddesign.com.au/features/product-in-focus/new-tools-add-accuracy-and-efficiency-to-metromap>

<sup>186</sup> <https://www.channelnewsasia.com/news/singapore/punggol-digital-district-jtc-physical-digital-infrastructure-12271746>

<sup>187</sup> <https://www.computerweekly.com/news/252480432/Singapores-JTC-taps-GIS-platform-in-Punggol-Digital-District>

<sup>188</sup> <https://news.curtin.edu.au/stories/from-wa-to-the-moon/>

<sup>189</sup> <https://www.arose.org.au/>

Elsewhere in the region robotics thrived this quarter, with **Singapore deploying robots** across the country to **assist in the battle against the virus**; whether this is through the autonomous cleaning robot developed by **DiSa to clean rooms using UV light**, the hallway cleaning autonomous robot Ella, or the BeamPro, a robot designed to **deliver food and medicine** to patients who have tested positive for COVID-19 to reduce staff exposure to the virus.<sup>190,191,192</sup>

These are just a handful of solutions developed and deployed in Q1 that showcase the **increasing importance of robotics development to the health and wellbeing of people**, with benefits ranging from protecting the lives of healthcare workers, reducing the usage of the limited stocks of PPE during the pandemic, or reducing the transmission of virus' throughout the hospital.

## 7.4.2 Climate Change

International coordination is seen once again in the Australasian region, with **Air New Zealand joining NASA's Cyclone Global Navigation Satellite System (CYGNSS)** as part of a coordinated effort to **tackle both Climate Change and Cyclone prediction**.<sup>193</sup> Air New Zealand will be fitting their Q300 turboprop aircraft with **next-generation satellite receivers** to gather data such as wind speed and soil moisture levels. Once this has been implemented in all 23 of the airlines Q300 aircraft this data is likely to be the **largest source of environmental data in New Zealand** and it will be essential to improve the flood risk management and agriculture industries of New Zealand

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<sup>190</sup> <https://www.asiaone.com/digital/singapore-rolls-out-autonomous-disinfection-robot-can-maybe-kill-covid-19-shooting-uv-light>

<sup>191</sup> <https://asia.nikkei.com/Business/Technology/Hygiene-obsessed-Singapore-deploys-robots-to-keep-coronavirus-away>

<sup>192</sup> <https://www.bangkokpost.com/world/1872349/robot-to-deliver-meals-medication-to-covid-19-patients-in-spore>

<sup>193</sup> <https://spacewatch.global/2020/02/air-new-zealand-joins-nas-a-climate-science-mission/>



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