What is a liveable city?

What is a quality life?

What is Smart City 4.0?

Standing at the forefront of science and technology, grasping the global trend, the author explains Smart City 4.0 thoroughly. She points out how various stakeholders in the society can use startups in the post-epidemic era, through a geographic information system (GIS) platform, to predict the risk of virus transmission, improve urban planning and mobility efficiency, and promote communication between the government and citizens.

This book contains the best practice of nine real life applications in Hong Kong, a number of overseas cases and large amounts of data to outline the huge business opportunities brought about by smart city development. Furthermore, this book deeply analyses the advantages of Hong Kong. Through this book, readers will clearly understand the overall trends, allowing them to equip themselves to meet new opportunities in the post-epidemic era.

GIS: The full name is geographic information system. It is valuable information generated from geospatial locations linked with terrain, weather, buildings, traffic, and other data that assists users in making a more informed decision and increasing productivity.

SDI: The full name is spatial data infrastructure. It is a collective term for policies, standards, and resources formulated for the collection, management and use of geospatial data. With the broad use of spatial data in governments and various industries, many countries such as Europe, the United States, the United Kingdom, Australia, and Canada have established their national-level SDI.

SMART CITY 4.0

By Dr Winnie Tang

What is a liveable city?
What is quality of life?
What has gone wrong on earth?

Smart City expert Boyd Cohen defined “smart city” in 2015 as follows:

Smart City 1.0: technology-centric.
Driven by technology providers, cities adopt technical solutions when they have not fully appreciated how these technologies may impact a citizen's quality of life.

Smart City 2.0: technology enabled, city authority-led.
City administrators increasingly focus on technology solutions as a means to improve quality of life.

Smart City 3.0: citizen co-creation.
To strike a balance between conservation and development, a bottom-up approach is used to drive city growth.

A new phase Smart City 4.0 has emerged during the post-Covid-19 era. The 4.0 version further zooms as the driving force of smart city development in which both startups and the geographic information system (GIS) play an indispensable role.

From healthcare, transportation, and city management to vegetation, GIS helps forward-thinking organisations, from all levels of government, institutes and the public, startups in particular, to make use of GIS together with advanced technologies in guiding development efforts and conservation, at the same time maintaining constant awareness of a community’s aspirations and staying connected with all of the stakeholders.

SMART CITY 4.0

I would like to dedicate this book to the startups which make good use of innovative technologies. Thank you for bravely taking the first step, your perseverance in improving society allows us to enjoy a better life.

Preface

Never forgetting her original intentions: How Winnie and GIS are inextricably linked

Esri China (Hong Kong) is celebrating its 25th anniversary in 2022. Over the past 25 years, the company has experienced ups and downs, while Winnie has been able to keep on course. I am always amazed at how brave she has been along the difficult journey.

Although Hong Kong is only a small city with a population of more than 7 million, it was one of the former Four Asian Tigers, and is an international financial centre in rank with London and New York. But in the early years, the government, public and private organisations lagged behind in the application of innovative technology. I remember in the 1990s, shortly after graduating from university, Winnie came to the U.S. headquarters alone in the hope of obtaining the exclusive right of acting as the sole agency for our geographic information system (GIS) in Hong Kong.

My company and Winnie are of the same age. More than 20 years ago, governments, private and public sectors of the U.S. and many developed countries started to adopt our software to replace paper maps, together with other spatial data for analysis and planning. GIS allows you to see an “abstract reality”, that is, to see relationship in between and enhance understanding of issues from a holistic perspective. From urban planning, flood mitigation, environmental protection, retail business expansion, and logistics to transportation and mobility and more, GIS can enable a better-informed decision. As an industry leader, how could we delegate a young lady with neither business experience nor a sales track record to be in charge of our business in Hong Kong?

But Winnie did show extraordinary courage and determination. She was teaching at the university with a stable income at that time, but she was determined to go for business, with the aim of promoting the competitiveness of Hong Kong, her home city, and increasing the quality employment opportunities for the younger generations. She was convinced that making good use of the advanced technologies such as GIS was key.

To achieve this ambitious goal, GIS must not be left in the university's ivory tower, Winnie has to establish an ecosystem and apply GIS through commercialisation, so that the industry can attract more young people to join and bring in more innovative ideas to enable the further development of Hong Kong.

In this way, under her considerable efforts, Hong Kong's business is booming, the application is becoming more embracing, from the population census, the water main network, environmental law enforcement, natural disaster relief, and urban planning to airport management; all have used GIS to enhance efficiency.

But she has never forgotten her original intentions. So I'm not surprised that she has handed over the business to colleagues in recent years and spent

most of her time perfecting the ecosystem. In the last few years, Winnie has not only founded the Smart City Consortium (SCC), liaising with a group of professionals from different sectors to provide advice and suggestions to the government for smart city development, but has also contributed money and time to students in order to nurture local talent.

Six years ago, she launched the Map in Learning programme, which offers the professional ArcGIS software free of charge to primary and secondary schools throughout Hong Kong, with free training for teachers. Her Young Scholar Award encourages students in tertiary education to analyse their selected issues with GIS, from environmental pollution, and traffic black spots to site selection for columbaria, all to help fully realise youngsters' potential.

In addition, she also started teaching master degree courses in computer science in the Engineering Faculty at her alma mater, the University of Hong Kong six years ago. Then she extended her teaching to HKU's Social Sciences Faculty and Architecture Faculty as well as master degree courses for other local universities on smart city and digital transformation, including the Hong Kong University of Science and Technology's Division of Public Policy, Lingnan University and the EMBA programme of the Chinese University of Hong Kong.

Winnie also reached out to China and the wider region. She shared her insight with leaders of private and public sectors in China and the Asia Pacific region in prestigious international seminars. She has also been repeatedly invited by the Asian Productivity Organization to offer her advice to a number of government officials on how to pave the way towards a smart city.

Furthermore, in order to encourage future generations, she has set up five scholarships for local university students and young people, the latest of which is designated to local startups to support seedlings. That was her original intention 25 years ago: to enhance Hong Kong's competitiveness, we need to create an ecosystem in which young people are the indispensable element, and she is honouring her promise.

2020 was an extraordinary year in the history of the Earth, but it is actually not a surprise. The Covid-19 pandemic, global warming, and threats to biodiversity are reminding us that we must use a broader perspective to solve global problems. Using GIS, organisations can look at data from a variety of sources, including demographic characteristics, weather, traffic flow, social sentiment, infrastructure, and terrain, to combine indoor and outdoor data with satellite imagery and various real-time information, and spot patterns, trends and insights that previously would remain buried in data, and all these enable them to make better decision.

In early February 2020, right after Johns Hopkins University launched the world's first interactive map dashboard on Covid-19 outbreaks, Winnie brought forward the Hong Kong version: "Novel Coronavirus Infection in Hong Kong" with the effort of the government's various bureaux and departments. The map based dashboard combines key outbreak information and has a stabilising effect on public perceptions. Winnie, meanwhile, continues to advocate for the government to open up more urban spatial data, and to strengthen cooperation between departments to prepare for a new wave of outbreaks.

Her new book, *Smart City 4.0*, is both a review of the past 25 years, and is forward-looking. I am particularly glad to see successful stories from nine public and private organisations and the government, and how Hong Kong has made great progress through the application of advanced technology. These are also the results of Winnie's years of hard work.

The digital transformation has become a global trend, the massive amounts of data it can master is why GIS can play a critical role. When it comes to what we could create with GIS, the sky is the limit. So let's co-create a more sustainable and smarter future together!

Jack Dangermond
Founder & President, Esri

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Export smart city intelligence to capture huge business opportunities

The smart city brings unlimited business opportunities of which the global value is expected to reach HK$12 trillion by 2025. Southeast Asia has a great demand for smart city applications, countries can learn from Hong Kong, subsequently creating unlimited opportunities for us.

1.1 Trillions of business opportunity in ASEAN countries

The United Nations estimates that 68% of the world's population will be living in a city by 2050, making the cities very crowded. The influx of people is due to more work opportunities there. Consulting firm McKinsey pointed out that by 2025, 600 cities would account for 60% of the global GDP growth. To solve the accompanying problems such as housing, security and employment, further development as smart cities has become a global consensus.

Due to the envisaged giant project size, different research reports anticipated great business opportunities in these smart cities. For example, market research companies CB Insights and Frost & Sullivan both predicted that by 2025, the global value of smart city developments would range from US$1.4 to US$1.56 trillion, close to the GDP of South Korea, Russia or Australia.

Strong economy but poor infrastructure

Among them, the demand for smart city services is especially high in emerging countries, such as in the ASEAN countries.

The world has been suffering from the setback brought by the Covid-19 pandemic. However, the International Monetary Fund predicted in June 2020 that the economy of the five ASEAN countries (Indonesia, Malaysia, the Philippines, Thailand, and Vietnam) would rebound rapidly by 6.2% in 2021, and India, a populous country, would also rebound strongly by 6%, far above the 4.8% of the advanced economies.

> *"Hong Kong has excellent global smart city rankings, and the ability to export smart city related services to the ASEAN countries creating employment opportunities for local talent."*

In recent years, the economic growth of these countries has been impressive. For example, Vietnam's manufacturing industry has emerged and developed rapidly, but the country's infrastructure cannot keep up with the economic development.

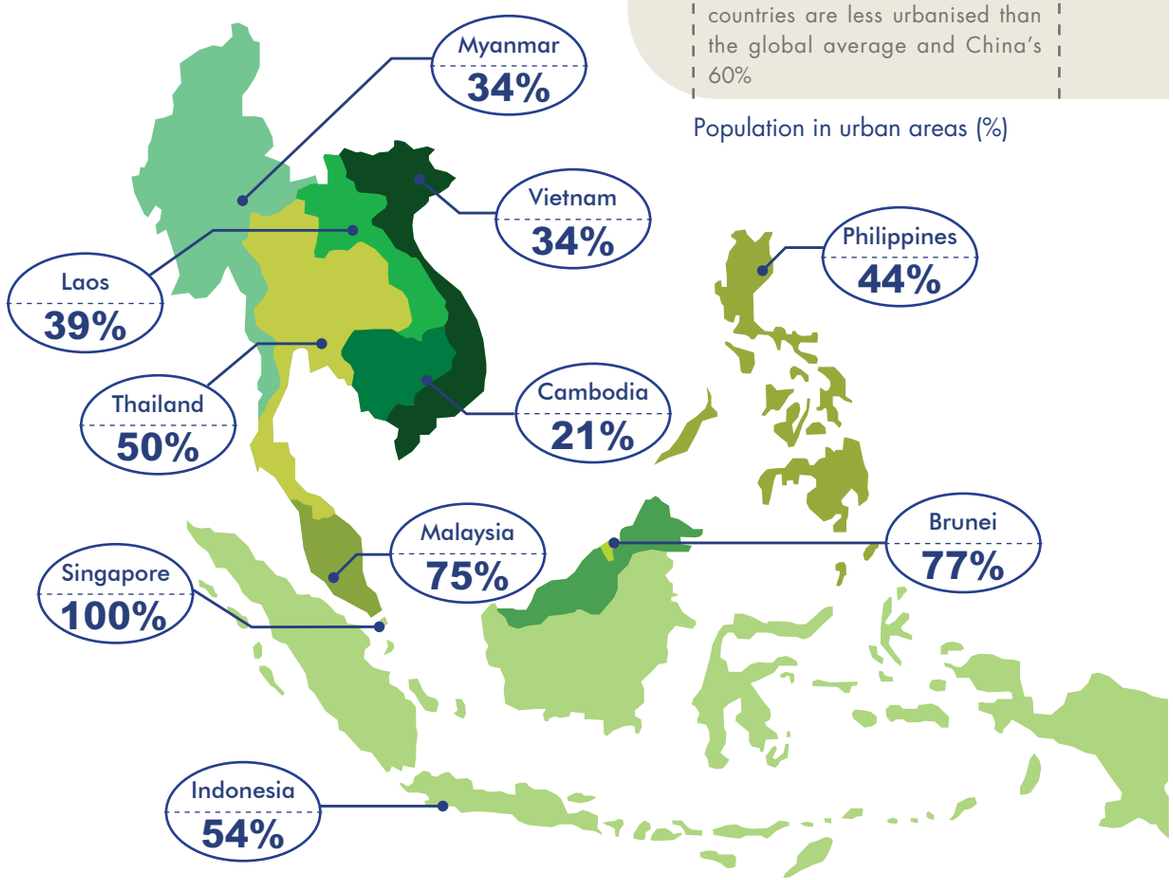
According to the estimation of McKinsey, six ASEAN countries are less urbanised than the global average of 54% and China's 60%. The lowest is Cambodia (21%), followed by Vietnam (34%), with the middle being Thailand (50%) and Indonesia (54%).

At the same time, the rapid economic development has attracted many migrants to the cities, causing problems such as insufficient housing, poor water supply systems and air quality, a huge income gap between urban and rural dwellers, and poverty and public security issues. Other city infrastructure such as waste collection and treatment, street lighting, power grids, transportation systems, education and healthcare are all in need of immediate improvement.

Most ASEAN countries are less urbanised.

Urbanisation in Southeast Asia is relatively low: **6** out of **10** countries are less urbanised than the global average and China's 60%

Population in urban areas (%)



Source of info: McKinsey Global Institute

Call for smart cities

In view of the situation, the Vietnamese government has formulated a series of national policies for the development of the smart city. For example, there are documented guidelines related to the construction and planning of the smart city, its related investment plan, as well as IT infrastructure, such as the first document issued by the Prime Minister in August 2018 and an ICT reference framework released in 2019. The pilot projects on smart city have been launched in several cities, including Ho Chi Minh City, Hanoi, Da Nang, and Hai Phong.

However, to date, Vietnam is still in its infant stage. With reference to the ranking of the IESE Cities in Motion Index 2020 (IESE) by the Spanish IESE Business School, Ho Chi Minh City was only ranked 127th. The city needs to catch up in the areas of human capital (156th), governance (158th), economy (142th), technology (125th) and more.

India is also on the IESE list with four cities, among which Bangalore was ranked the highest: 146th. The situation in other ASEAN countries is similar to Vietnam and India.

Where is Hong Kong's role?

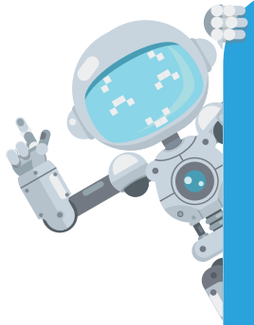
Currently, Singapore, South Korea, Taiwan, Japan, the United States and Europe are all actively seeking cooperation with these countries. For example, the ASEAN Smart Cities Network (ASCN) set up by Singapore, has selected 26 ASEAN cities as pilot smart cities. South Korea also established the Korea Smart City Open Network (K-SCON) to share urban development experience and solutions with the ASEAN countries. While India invested US$75 billion in building 100 smart cities under the Digital India initiative,

the plan has received enthusiastic responses from American companies such as Google, Facebook, and Qualcomm.

While all advanced economies are rushing to capture the business opportunity in smart city development, why does there seem to be a lack of interest from Hong Kong?

Over the past few years, Hong Kong has experienced social turmoil and the Covid-19 pandemic. However, judging from the international rankings, the international society sees that Hong Kong's performance keeps improving. One of the examples is the IESE rankings, Hong Kong's ranking rose from 27th in the world in 2017 to the 10th place in 2020; third in the Asia-Pacific region, following Tokyo and Singapore. With a strong position in the world's smart city ranking, why can't Hong Kong be more proactive in promoting its smart city expertise to other countries?

To find a new market for Hong Kong's service industry and talents, we should strive to partner with ASEAN cities, exchange and assist in the development of smart city standards, and promote the export of related solutions and services.



The global value of smart city is close to the GDP of South Korea, more than that of Australia, Spain, Mexico, or Indonesia.

Global value of smart city US$1.56 trn

GDP in 2019 (US$, trn)				
1.6	1.3	1.3	1.2	1.1
South Korea	Australia	Spain	Mexico	Indonesia

Source of info: World Bank, CB Insights, Frost & Sullivan

1.2 Exporting smart city services to create opportunities for local talent

In order to catch up with the soaring economy, the ASEAN countries and India have adopted a smart city strategy. Many countries including Singapore, Japan, South Korea, and the United States, are striving to seize this trillion-dollar business opportunity. Hong Kong, which also stays at the top in different international smart city rankings, seems to have lagged behind in this aspect.

According to government data from August 2020, the ASEAN countries are Hong Kong's second largest trading partner. The bilateral merchandise trade accounted for 12% of Hong Kong's total merchandise trade, reaching over HK$1 trillion in 2019. The ASEAN region is also one of Hong Kong's four largest foreign direct investment destinations; it has close ties with Hong Kong.

Singapore's ambition

However, why didn't we further extend our ties to the area of smart city, including the supply of software and hardware as well as consulting services? This arises from the Hong Kong government's positioning the smart city only as a domestic affair and not considering it as a service which can have a great business value for export.

Singapore has a completely different strategy. Early in 2014, Prime Minister

> *"Hong Kong should learn from Singapore to uplift its branding of smart city so that Hong Kong can grasp the opportunities of smart city related businesses."*

Lee Hsien Loong officially positioned Singapore as a "smart nation". In addition to launching a series of information technology measures to improve people's livelihoods, such as coping with the ageing population and enhancing its own smart national power, the country is also active in strengthening its international influence. The result can be witnessed in its top ranking from different organisations. The Spanish IESE Business School's global smart city ranking is one example, the *IMD World Competitiveness Ranking 2020* from the International Institute for Management Development in Switzerland ranks Singapore first in both the Asia-Pacific region and the world is another illustration. After building up a strong brand, it is easier for the country to dominate smart city cooperation with others, especially the ASEAN countries.

To overcome civil servants' inertia

As for Hong Kong, we have gained international recognition in many aspects, including the application of science and technology measures, human resources and more, these experiences are all aspired by the ASEAN countries that want to develop their digital economy. Besides having close business contacts with ASEAN countries, we enjoy the right timing and

locality advantage. However, if Hong Kong wants to get a share of the huge smart city business opportunity in ASEAN countries, we must strengthen the following three aspects that concern people:

- Overcome the inertia of civil servants: Civil servants must evolve from a service provider to a service promoter. While maintaining a high service quality, they must also think about how to persuade people/government to adopt the new technology. Such a huge change needs to be promoted in a top-down approach. At the same time, they would certainly be inspired by the demonstrations of foreign governments at various international conferences.

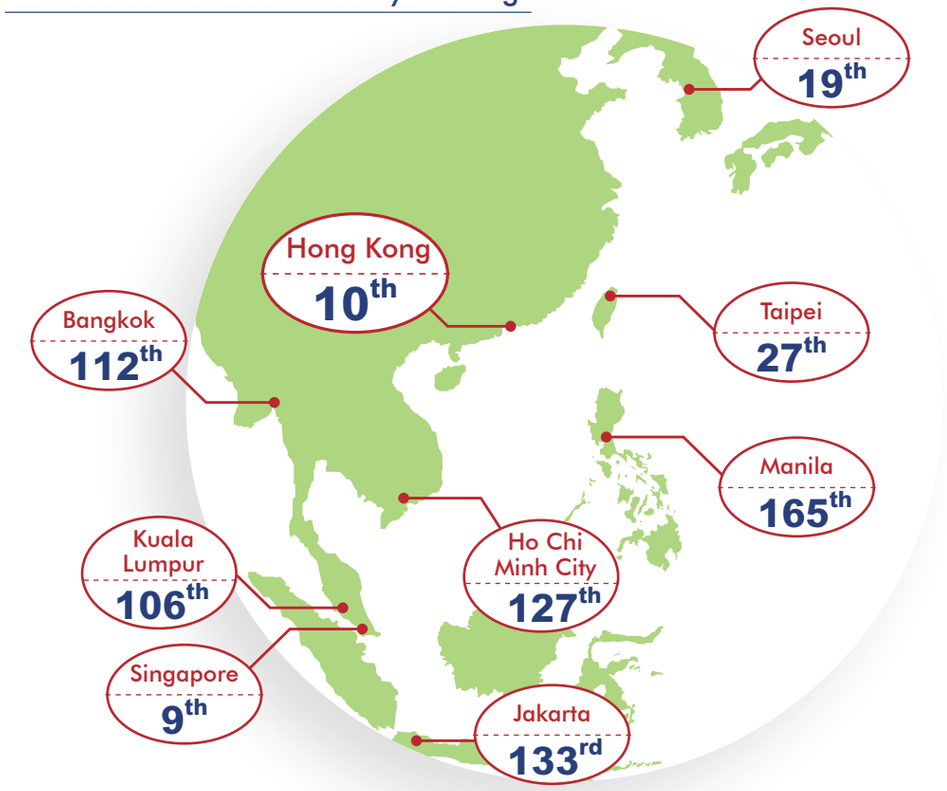
- Consolidate human resources: Talent is the key to success in every undertaking. Hong Kong's educational achievements have been renowned internationally over the years. We should continue to strengthen students' training in STEM, computer programming, and broaden their international horizons, so as to ensure continuous growth in Hong Kong's talent pool.

- Enhance social cohesion: This is currently the weakest dimension of Hong Kong (111th) in the IESE Business School's global smart city ranking. In recent years, the society is unstable, it is difficult to achieve anything even with good intentions. Enhancing the transparency of governance and gaining mutual trust to unite people is the only way forward. At the beginning of 2020, the Covid-19 virus began to spread in Hong Kong, so did rumours. To improve information transparency, the government swiftly launched an interactive map dashboard listing important pandemic information which immediately stabilised society in face of the outbreak.

Hong Kong's leadership position

Compared with Shanghai (58th), the highest IESE smart city ranking in 2020 among the Mainland cities, Hong Kong (10th) has significant advantages. Therefore, we must take our leadership seriously so as to capture a large share of the huge business opportunity.

Hong Kong is ahead of over 100 cities in terms of smart city ranking.



Source of info: IESE Cities in Motion Index 2020

1.3 The first step in developing smart city: understand your strength

All of the Asian developing countries participating in the Asian Productivity Organization (APO) held in Seoul in 2019 showed their eagerness to develop the smart city as a solution for their various urban problems.

Let's briefly introduce APO first. Being a regional intergovernmental organisation with its headquarters in Japan, it was founded in 1961. It has 20 member economies, apart from the former Four Asian Tigers, i.e. Hong Kong, Taiwan, Singapore, and South Korea, as well as Japan, there are Bangladesh, Cambodia, India, Indonesia, Iran, Fiji, Laos, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam. APO is like a think tank offering ideas and suggestions for the development of industry, commerce, agriculture and public sectors to the member economies.

Countries like the Philippines and Indonesia are very rich in natural resources but also face common issues like ageing, severe traffic congestion, and air pollution amid the emergence of urban development. How can they proceed when it comes to smart city development? What should be done in the very beginning to ensure the success of smart city implementation?

In the APO's Smart City Workshop, a participating university professor from the Philippines shared the development of a plan for Manila launched in

> *"In developing a smart city, it is most important to solve the local problems in the right way, and gain public support. Technology plays a supporting role in this regard."*

2012, linking 16 cities as a metropolis of Manila, accounting for 33% of the national output. The *Metro Manila Greenprint 2030* spans 20 years with the aid of the World Bank, Australia, and Japan. According to the Chairman of the Metropolitan Manila Development Authority, the plan has several goals:

- Building the capital as an "economic powerhouse in East Asia", and creating a comfortable, affordable and safe living, academic and leisure environment that allows the public to live and work in peace;
- Create quality jobs that enable talent to apply their skills – for example, target to increase the positions created by the IT industry and outsourcing work to 6.3 million by 2020, 2.5 times of that in 2012;
- Convenient transportation and reduced environmental pollution; there must be a sound and reliable infrastructure to cope with the challenges of natural disasters and climate change;
- Most importantly, integrate all areas of Metro Manila as a unified metropolis for both the poor and the rich, encouraging people to work together in constructing the metropolis.

However, after a few years' effort, many old problems still remain, and there are slums in the capital as reported by a local newspaper. At the same time, there is a lack of science, technology and innovative culture as the government has not allocated enough resources to these areas. As a result of talent shortages and insufficient related infrastructure, the ecosystem has not been formed.

To enable good planning, in my opinion, countries should first assess their strengths, e.g. in terms of natural resources both undersea and on land. Developed countries like the United States, the United Kingdom and Australia have made wide use of the geographic information system (GIS) to thoroughly investigate the potential of their natural resources at home so that they know how to leverage their own strengths.

In this aspect, Hong Kong actually has solid experience to share and export.

For example, the Hong Kong government has introduced advanced GIS for decision-making more than 20 years ago, a pioneer in the Asia-Pacific region. Nowadays, government departments and corporations have widely adopted advanced technology for planning urban development, tracking disease outbreaks, guiding business expansions, and supporting disaster relief. One of the examples is the introduction of an Interactive Map Dashboard for Covid-19 in early 2020 where, through the joint effort of the government's various bureaux and departments, their open data was integrated to help contain the epidemic.

While Singapore and South Korea are ambitious to grasp the golden business opportunity, the Hong Kong government should speed up improving the spatial data infrastructure through the provision of more public data as soon as possible, it will certainly support us in exporting our advanced techniques to neighbouring countries. By doing so, Hong Kong will not miss out on the trillion-dollar business opportunities from ASEAN countries and neighbouring cities, and the initiative will also help inject new impetus into the Hong Kong economy.

1.4 Vietnam's challenges, Hong Kong's opportunities

According to consulting firm Frost & Sullivan, the smart city's global market potential in transportation, healthcare, construction, energy, infrastructure, and governance can reach as much as US$1.5 trillion. No wonder Arun Kumar, former Assistant Secretary for Global Markets at the U.S. Department of Commerce said that many Asian and ASEAN cities had emerged and created many business opportunities.

In 2019, at a smart city workshop organised by the Asian Productivity Organization (APO) which invited me as a mentor, I witnessed that many countries have already been working hard to explore business opportunities to develop the smart city. Hong Kong should not lag behind.

Many of these member economies, like Thailand, Vietnam, Indonesia, India, and the Philippines, have emerged as significant players in the world economy in recent years. Among them, a common approach is that most participants hope to solve their current problems through the application of smart technology.

Technology may not be answer to urban problems

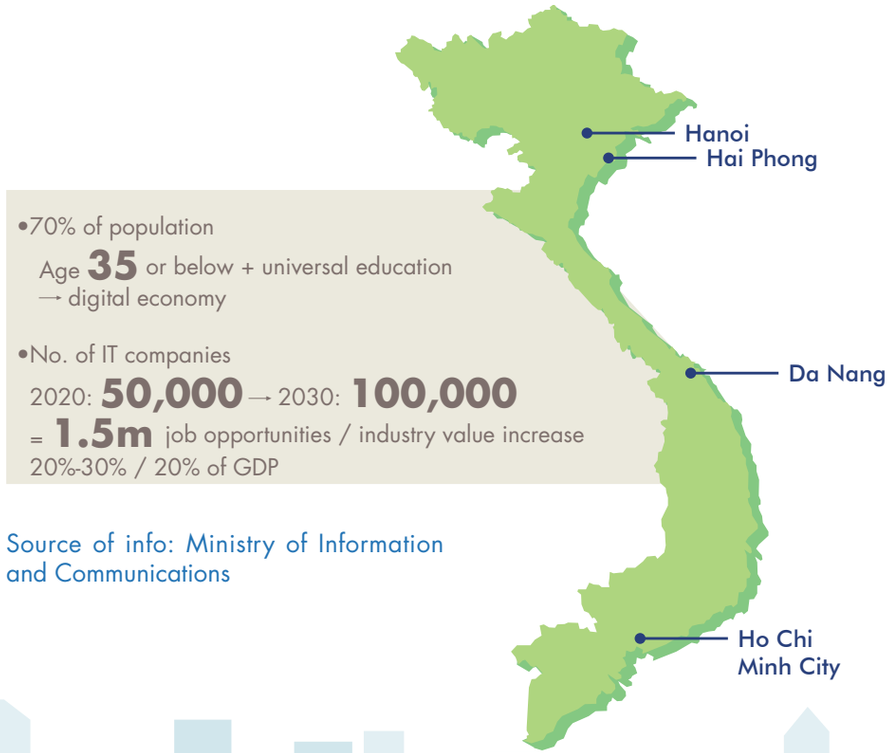
During a five-day conference in Seoul with the theme Workshop for Developing Standards for Smart Cities, the audience was comprised of government representatives and scholars from member economies. We talked about the global technology trends in smart city development, how open data could unlock innovation and economic advantage, how to develop the standards of a smart city, a roadmap, and lessons of our own regarding a smart city.

> *"Hong Kong is more advanced than many Asia-Pacific cities. For example, the government has adopted GIS in decision-making, with the financial industry having gone through digital transformation."*

In one of my speeches, I mentioned that the development of a smart city could be divided into 10 steps. The key is the first one: to work out what problems really need fixing.

Many people may think that simply applying loads of new technologies, such as the internet of things, big data, and artificial intelligence would enable a city to be smart. However, when there is traffic congestion in an emerging city, it is not appropriate to jump to the conclusion that a monitoring network should be installed on the main roads, because the real problem might be that the public transport capacity cannot keep up with population growth. If you don't address the crux of the matter, you will waste resources, cannot deliver the expected result, and will lead the public and the government to become sceptical of smart technology.

Vietnam's InnoTech outlook with 4 cities having pilot projects on smart city development



- 70% of population
  Age **35** or below + universal education
  → digital economy
- No. of IT companies
  2020: **50,000** → 2030: **100,000**
  = **1.5m** job opportunities / industry value increase
  20%-30% / 20% of GDP

Source of info: Ministry of Information and Communications

Case study of Ho Chi Minh City

The participants all gave enthusiastic agreement to the above view and shared their problems. For example, the situation in Ho Chi Minh City, Vietnam is quite typical. The Vice Director of the Department of Science and Technology expressed their wish to develop Ho Chi Minh City into a smart city by 2025, so as to help solve the City's major problems. The key issues faced are -

1. Rapid population growth: As Vietnam's centre of economy, finance, trade and technology, Ho Chi Minh City is home to more than 8 million or 9% of the country's population. Since 2011, a large number of migrants have poured in, the population grows by an average of over 2% a year, leading to problems in healthcare, housing, public order, transportation, and pollution. Naturally, the city's infrastructure cannot keep up with the population growth.

   – In fact, Hong Kong experienced the same problems as a result of the influx of immigrants from the Mainland during the 1950s and 1960s, but then we overcame the challenge and became, as today, an international financial centre and one of the Four Asian Tigers. Our successful story may give inspiration to Ho Chi Minh City.

2. Declining competitiveness: Although its industry has been growing rapidly with contributions to the national GDP at 18-21%, its export ratio compared to other provinces in the nation is declining. The ranking in the Provincial Competitiveness Index (PCI) has confirmed this worry.

   – This is the same problem that Hong Kong is facing today; we have invested

heavily in innovation and technology to reverse the trend. We open data actively and seek to strengthen cooperation with neighbouring cities such as the Greater Bay Area to promote innovation and economic development.

3. Increasing public expectations of the government: The city's annual income per capita continues to increase, reaching US$5,538 in 2015, which is an increase of more than 70% compared to 2010. The strong income growth has also raised the public's demand and expectation on health, education, transportation, environment, and public services. This naturally brings a lot of pressure to the government. However, due to the lack of comprehensive use of information technology in urban management, the government's planning and forecast of the city's needs were not as effective as they could have been.

   – It is common for people in developing places to have high expectations exceeding the capability of the government. The best way to tackle the issue is to increase transparency in governance. Through opening data and the constant update of matters related to people's livelihood, such as transportation, housing, employment, etc., like the Mayor's Dashboard in Los Angeles, U.S., and Hong Kong's interactive map dashboard, "Coronavirus Disease (Covid-19) in Hong Kong" the public can be provided with one-stop updated information of the epidemic, which greatly eased the tensions of the general public. This epidemic dashboard has attracted more than 58 million views by the end of 2021. It is another case to demonstrate the success of sharing information.

Hong Kong's experience in smart city development

Can't you see that Hong Kong is in a very strong position to assist ASEAN countries to develop smart cities? However, outside Europe and the U.S., Singapore and South Korea are also very ambitious in exporting their smart city experience. For example, Singapore led the establishment of the ASEAN Smart Cities Network (ASCN), attracting 26 pilot cities in the region from countries such as Myanmar, Laos and Vietnam. South Korea is also committed to promoting the same idea to the Middle East, South Asia and South America, it claims to have 100 smart city projects with India. At the same time, Taiwan's international influence may not be as substantial as others, but from the sharing of a few cities, such as Taipei and Kaohsiung in this meeting, they also have huge potential to export smart city experiences.

Compared with them, the Hong Kong government introduced advanced information technology more than 20 years ago – we have been adopting the geographic information system (GIS) for analysis and decision-making earlier than many cities in the Asia-Pacific region. In 2018, the Lands Department took the lead in linking datasets of various government departments, and spatial data infrastructure is already in shape; smart city projects such as smart lampposts have been launched; plus financial initiatives such as opening more data through application programming interfaces (API) and issuing virtual bank licences, and more. All these initiatives show that Hong Kong has established credentials in assisting ASEAN countries and neighbouring cities to develop the smart city. If the Hong Kong government can speed up and improve its spatial data infrastructure as soon as possible, it will certainly help our export of expertise and technology.

1.5 How Shanghai builds its smart city

When the epidemic was at its peak in China in early 2020, the Shanghai Government released a submission on speeding up the construction of its smart city infrastructure. The better use of big data and smart technology is suggested to enable more accurate and scientific decisions for epidemic control. A couple of its recommendations deserving our attention are summarised as follows:

- Share and open data for new applications: The submission proposes open urban public datasets, the development of cross-departmental data sharing mechanisms and big data joint innovation laboratories among different industries for new data applications.

  In Hong Kong, the government also has similar ideas to promote innovations. A Smart Government Innovation Lab was proposed in the *2018 Policy Address*, inviting the industry to put forward proposals on new information technology solutions and products. The *2020 Budget* also reserved another HK$60 million to set up the first Geospatial Lab to encourage the public to make use of spatial data in developing mobile applications.

  However, research and development require data, and the two labs need ample amount of it. It would make practical sense to make use of the existing set-up in the Hong Kong Science Park where a Data Studio, together with an online platform and its comprehensive facilities, has been established since 2017. I think the collaboration among the three will have a huge synergetic effect.

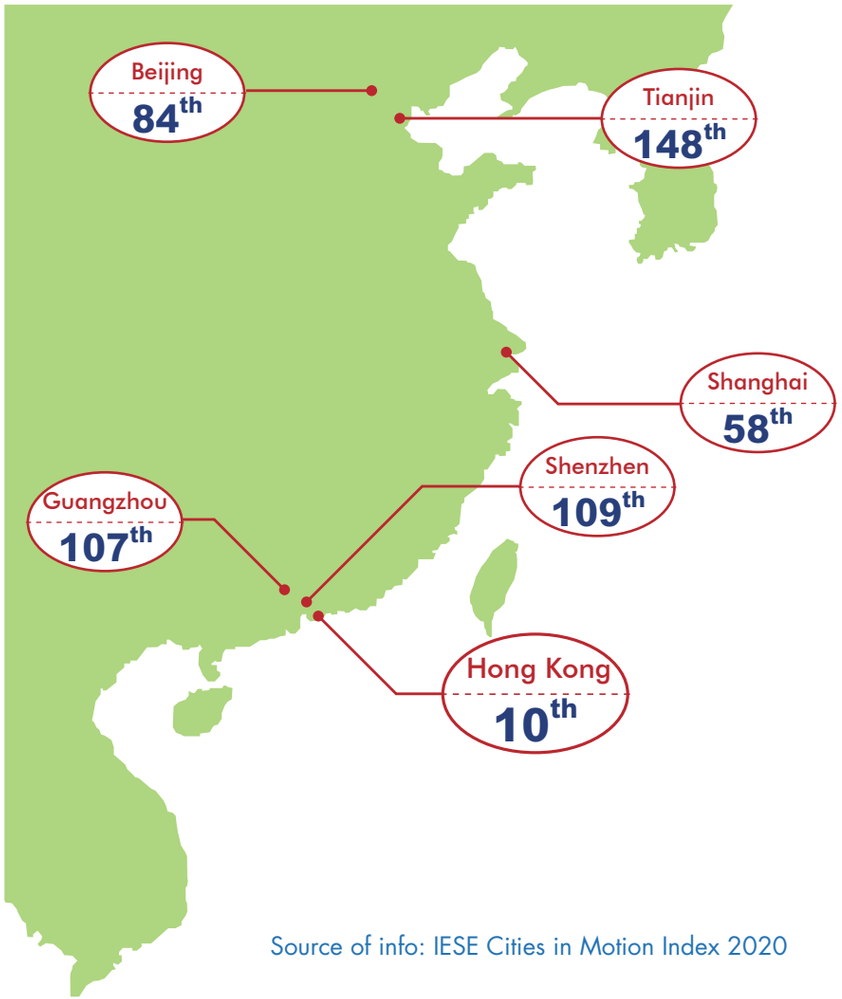
> *"With its international position, Hong Kong has an advantage over Shanghai in formulating smart city standards."*

- Improve the standards system: Formulate standards and certification testing, and work with enterprises to establish the safety testing system and standards for smart city applications.

  The submission from Shanghai is really competitive with respect to Hong Kong. However, Hong Kong's international advantage indeed gives the city more leverage in first formulating smart city standards.

  In fact, the Hong Kong government introduced advanced information technology for urban planning and management over 20 years ago. The city has been repeatedly ranked among the best Asian cities in different global smart city rankings, well ahead of all mainland cities. There is obviously an international recognition of Hong Kong's achievements.

Hong Kong is ahead of Mainland cities in global smart city rankings.



Source of info: IESE Cities in Motion Index 2020

Furthermore, the industry is actively developing international standards. For example, the internet of things (IoT) is an important part of a smart city, but there is a lack of widely recognised standards for the IoT and related devices such as sensors, making the security, compatibility, and accuracy of IoT devices questionable. In view of this, some scholars in Hong Kong have worked with the industry to set up the first standard – IEEE P2668 "Standard for Maturity Index of Internet of Things", which has been approved by the Institute of Electrical and Electronics Engineers (IEEE) as an international standard.

Although Hong Kong is still ahead of mainland cities in the development of a smart city, the gap is narrowing. Therefore, I hope the coming *Smart City Blueprint for Hong Kong 2.0* can assist in re-establishing Hong Kong's leadership position.

1.6 Location technology enhances understanding of complex issues

Do you remember the rescue operation of 12 youth football players and their 25-year-old coach of the Wild Boar Team who were stuck in a remote cave in northern Thailand in 2018? The dramatic rescue bid gripped the world. A film was released in the following year on the incident.

Rescue mission co-ordinated through GIS

Tens of thousands of volunteers around the world, including 2,000 soldiers, 150 Navy SEAL divers and countless people in Thailand as well as cave divers from China, Japan, India, Laos, Israel, Russia, Australia, Finland, the Czech Republic, Belgium, Denmark, the Netherlands, the United Kingdom, Canada, and the United States rushed to join the rescue operation.

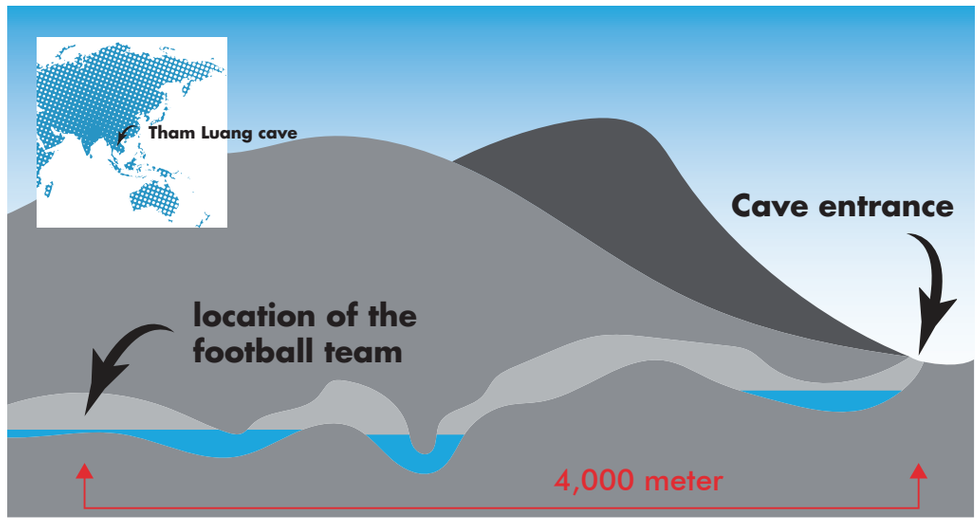
To effectively guide the operation, coordinate personnel and material supply, a comprehensive map is essential.

It was monsoon season at that time, the heavy rain can turn a peaceful stream into a torrent within minutes. The situation was worrying. Local expert climbers for bird's nests tried to explore the steep terrain in the cave with their generation-old technique. However, the area is too large and an individuals' effort is not enough to solve the problem. In such case, the geographic information system (GIS) and 3D digital map that integrated all data and information were used.

"The successful rescue of the Wild Boars football team in Thailand should be attributed to the 3D map and a digital twin that offered the best rescue plan."

Rescue at Tham Luang cave
- Inside: real-time data of water and oxygen level
- Outside: sensors on weather + data of previous expeditions

→ 3D map to find the best solution for rescue operation



In fact, in this rescue operation, maps were what the rescue team relied on to correlate the underground world to the land above, connecting the command centre and the rescue personnel.

In the beginning, the Thailand Department of Mineral Resources (DMR) invited GIS experts from Esri Thailand to create a series of maps to assess the possible location of the teenagers.

However, as the heavy rain continued causing the water level to rise rapidly, it was dangerous to dive and map the cave, as the water current can tear off a diving mask, and drag the diver away from the guide ropes.

Therefore, the mapping team changed their approach. They collected the cave data recorded in the previous expeditions, and produced a 3D map that visualised the waterways in and above the cave, as well as the dimensions of each waterway. At the same time, they set up sensors inside the cave at a reach of 1,500 meters to collect real-time data of water and oxygen levels. This was used together with the weather sensor to create a digital twin to simulate different situations, such as low and high water level, so as to find the best way for the divers to undertake the rescue operation safely.

After nine days of searching, the British diving experts finally found the team in a place more than two miles from the cave entrance and one mile underground.

GIS is like neural network

In the whole operation, the location software worked like the neural network of our body. It served as a platform to connect data from all sources, assisting the commander to quickly grasp the full picture of an incident, its patterns and the inter-relationships. As a result, the person-in-charge could respond in a timely manner.

That's why companies today also use the technology inside their offices to connect all parties and promote efficiency.

An oil giant in the United States has an office compound of 385 acres (about eight Victoria Parks) in Houston that can accommodate more than 10,000 employees and visitors. There are 250,000 sensors installed in the place to collect 400,000 data points every minute, and the company has integrated all information with indoor positioning software to produce a real-time digital location map so that it helps responses to emergencies (such as detecting carbon monoxide leaks), utilising resources (such as the temporary booking of conference rooms), and finding the best path between scattered office buildings. The indoor positioning also helps make the communication between customers and staff in real-time.

Today, the real-time sensor network and new data streams with location technology are changing how people understand the relationships and patterns involved in a number of complex issues such as global warming, natural disasters, diseases, crime, traffic, migration, population growth and social changes. Together, we are striving to build a smart future.

GIS enables staff to respond to emergencies, utilise resources, and find a path between scattered office buildings.

1.7 Applications of digital twin: from emergency management to town planning

In 2020, South Korea was not only hit by the Covid-19 epidemic but also suffered heavy damage during the monsoon season. Torrential rain accompanied by landslides washed away roads and houses, and the death toll exceeded 50, the highest in a year since 2011. Real-time monitoring of infrastructure and high-risk areas can help mitigate damage caused by natural disasters and allow the nation to respond more quickly. That is why the country is actively promoting the digital twin, which is also part of the 160 trillion won (HK$1.1 trillion) national strategy for the country's transformation, announced in 2020 as *Korea's New Deal*.

South Korea: Disaster management and redevelopment

Early in 2017, the South Korean government launched a digital twin programme to address various issues, such as traffic, crime, environmental pollution, energy management, urban planning, disaster management, and redevelopment with the hope of reviving the economy by improving smart travel and tourism.

> *The digital twin connects the virtual environment and the real world, it assists in the upgrade of old city facilities, and discovers business opportunities in the new development areas.*

Massive amounts of data are derived from the operation of the city. Through advanced technologies such as the geographic information system (GIS) and building information modelling (BIM) combined with 3D models, it is possible to accurately simulate the interior and exterior of a city's buildings, infrastructure such as roads and various pipes, as well as the surrounding terrain, and more. The digital twin goes one step further, it connects the virtual city with reality using technologies such as the internet of things (IoT) sensors, big data, and artificial intelligence, allowing the use of real-time data for analysis and monitoring in a replicated virtual city. For example, the digital twin is used in water systems in Incheon to monitor the flow of fine dust. In addition, various hypotheses can be added to predict the situation of natural disasters or the effects of new development projects, so that people can plan earlier.

Singapore: Enable urban planning

The Singapore digital twin programme is even more hotly debated in the industry. A few years ago, Professor Chris Webster, Dean of the School of Architecture at the University of Hong Kong, wrote in the foreword of my book *Are You Future Ready?*, that his former postdoctoral researcher was working with the Singaporean government and a famous American university "on the highest resolution model of transport and land-use interaction ever attempted for that city". One of the themes of the exploration is how to increase land supply, and the renovated cavern at Jurong Island is a successful example.

Singapore covers an area of 725 sq km (area of urban or built-up land in Hong Kong is 277 sq km) and has a population of 5.69 million (Hong Kong's is 7.47 million). In addition to maintaining green spaces, the government must coordinate housing with job creation while investing in infrastructure. The development of underground space, such as caverns, has become a focus in recent years.

In the western part of the reclaimed Jurong Island, which stores 126 million gallons of crude oil, the government is currently considering plans for underground utility plants, following the example of Helsinki's underground data centre. Underground projects also include extensive subway extensions in both the North-South Corridor and the Cross Island Line programmed for completion by 2030, and a deep tunnel sewage system scheduled for completion in 2024. Materials from the tunnel work will go directly to land reclamation, resulting in a further 10 % increase in reclaimed land by 2030.

U.K.: Better cost control

The infrastructure in the United Kingdom, such as London's sewage system which was built in the Victorian era, has long been inadequate and is not able to cope with the capacity of today's urban population. The U.K. government is aware of the problem, and two main directions have been formed in this regard:

Firstly, there is a need to digitise the infrastructure for improving the services, which also optimises the great potential of data. For example, it is estimated that digitising asset information of the U.K.'s rail network could save up to £770 million (about HK$7.7 billion) in the next eight years, while opening up public data can contribute an economic return of up to £8.9 billion (HK$89 billion).

Secondly, infrastructure investment is expected to exceed £600 billion (HK$6 trillion) in the U.K. over the next decade. How to ensure the budget is spent properly, how to reduce energy consumption, and create more synergies? The idea is to build them digitally before physically, that is to connect various digital twins, such as airport management, the power system, transportation, the environment, weather and other small systems into a cohesive national digital twin (NDT) to enable better-informed decisions.

"Using data for the public good"

The whole plan has far-reaching implications, so the government and the University of Cambridge have formulated a set of guidelines called *Gemini Principles* for public and private organisations to follow when constructing their own digital twins.

"Using data for the public good" as its core, the 9 principles can be summarised in the following three aspects:

- Purpose: Digital twins must provide a benefit to the general public, enable improvement in performance while creating value and must provide real insight into the built environment.
- Trust: Trust is a major element of the idea behind the NDT. A digital twin must enable security and be secure in itself, at the same time, it must be as open and transparent as possible and built using good quality data.
- Function: A digital twin must function effectively. A federation of digital twins must be based on a standard connected environment, there must be clear ownership of the twin, as well as clear governance and regulation. Its functions must also be able to adapt as technology and society evolve.

Establishing a digital twin is the same as setting up a smart city. The level of technology is important, but we must keep in mind the original intention, which is to put people first, serve the general public, and improve the quality of life. Therefore, I believe these principles are critical requirements.

1.8 Shenzhen demonstrates how 5G improves urban management

2020 is the first year of the fifth-generation mobile communication network (5G), lots of commercial applications can be found in the Mainland, especially in Shenzhen.

Compared with mobile networks in previous generations, 5G can greatly increase the download speed of data and shorten the response time (that is "low latency"). It relies on base stations that are densely distributed for signal transmission. By the end of October 2021, Shenzhen has built 50,000 5G base stations, with an average of 24.68 base stations per square kilometre, the highest density in the country. It is rated as the Best City for a 5G Standalone Network by the Ministry of Industry and Information Technology.

5G not only drives the economy of a city, but also enhances its competitiveness. Shenzhen has launched 5G application projects in many areas, including urban management, healthcare, education and tourism, to realise the value of 5G.

In urban management, for example, it demonstrates how 5G applications can benefit people's living and even the industrial and commercial sectors, from epidemic prevention, and the detection of criminals to assisting citizens and enterprises to enhance efficiency.

> *"Shenzhen's applications of 5G in urban management, healthcare, and education benefit its citizens and increase competitiveness."*

Anti-epidemic measures launched by Shenzhen include 5G robots equipped with six video cameras that can quickly measure body temperature, recognise facial features, and provide early health warnings, reducing the risk of infection caused by close personal contact.

With the real time detection of illegal parking and unlawful driving on the road, smart police cars can be dispatched. Many of these police cars are equipped with a self-driving function, plus artificial intelligence (AI), video cameras and sensors, which can collect information such as facial images and vehicle characteristics. Through the 5G network and the central database, real-time matching can quickly identify illegal vehicles.

But among all 5G applications, the most impressive one for citizens is an integrated online platform launched by the government. The one-stop platform will automatically match the relevant information to matters of concern for citizens who intend to apply and get approval for something. It only takes a few seconds from submitting the application to receiving the approval.

Shenzhen's 5G applications

Epidemic prevention	• robots with 6 video cameras • quickly measure body temperature, recognise facial features, provide early health warning
Detection of criminals	Smart police cars • with self-driving function + AI + video cameras + sensors • real-time matching of facial and vehicle images with central database • quickly identify illegal vehicles
One-stop online platform	• 100+ commonly used government functions • For applications such as talent introduction, old age allowance, business registration, e-hailing driver's licence • Application and approval can be completed within seconds

Source of info: Shenzhen Government Online

This platform is actually a cross-departmental and cross-level central information sharing platform. Through technology such as AI, big data, and the blockchain, data of population, housing, electronic certificate licences, public credibility, can be connected and used to process applications for talent introduction, old age allowance, business registration, e-hailing driver's licence, and more. The platform was officially launched in September 2020, covering 58 commonly used government functions in nine departments, and another 60 functions in early 2021. At the same time, it provides a variety of channels, including web pages and mobile applications. The platform provides convenient services and saves people's time; it also helps companies reduce operating costs.

Besides, some pilot projects using 5G have also been carried out in medical services, such as the review of drug prescriptions, remote consultation, mobile monitoring of intensive care units, and spinal surgery using a mix of remote and on-site navigation, improving the quality of medical practices.

As for Hong Kong, the city has also progressed fast with the number of 5G base stations increasing to over 7,100 as of mid 2021, with an average of 25.96 base stations per square kilometre of our "urban or built-up land", matching Shenzhen's base station density. I hope that with 5G becoming popular, it will benefit the public and help increase the competitiveness of the city.

1.9 6G: Fusing city and suburb together

When the fifth generation of mobile network (5G) was commercialised, the world's major countries including China, the United States, Japan, South Korea, Finland, and more have started the research on 6G which is expected to be deployed by 2030. Although the configurations of technology and the frequency spectrum to be used in the 6G system are not yet confirmed, all countries agree that 6G will have a profound influence on our society and living. Among them, urban planning needs new thinking in the 6G era.

The world's first 6G white paper *Key Drivers and Research Challenges for 6G Ubiquitous Wireless Intelligence* released in 2019 from the University of Oulu, Finland, integrates the views of 70 top communication experts from various countries. It highlights the initial basic direction of 6G development.

The white paper predicts that 6G will be 10 to 100 times faster than 5G. For example, the 5G network speed is said to be 10-20 times that of 4G, which can allow the download of a 1GB high-definition (HD) video in 3 seconds, while in the 6G era, it is believed that 10 similar HD videos can be downloaded within 1 second.

In terms of coverage, the 6G wireless network is no longer limited to the ground, rather it is a seamless global connection of the ground, satellite and airborne network. The network signal can reach remote villages, so

> *"When 6G brings massive amounts of data, GIS can play a more important role in many fields, such as urban planning, population estimation, and renewable energy management."*

that patients in mountainous areas can use telemedicine, while children can receive education at a distance. 6G will also be deeply integrated with artificial intelligence (AI) and machine learning, its level of intelligence has greatly increased, making it more accurate to predict the weather, and then quickly respond to natural disasters.

Take driverless vehicles as an example. When driverless vehicles are in big cities, they need to be aware of their location, their changing environment, and other road users such as cyclists, pedestrians, and other driverless vehicles. They will need to negotiate through junctions and optimise their route in a way that minimises journey times. This requires the processing of large amounts of data, as well as the synchronisation, collaboration, and ultra-low latency of 6G. However, another essential factor for autonomous driving to be truly realised is corresponding urban planning, such as dedicated autonomous driving lanes, driving areas and restrictions. Meanwhile, the car park demand will significantly decrease because sharing driverless vehicles is expected to be a trend.

Telecom experts believe that 6G will be 10 to 100 times faster than 5G.

	5G	6G
network speed (download of a 1GB high-definition video)	3 second	10 videos within 1 second
peak data rates	10 Gbps	100 Gbps-1Tbps
indoor positioning accuracy	10 metres for outdoor	10 cm; 1 metre for outdoor
latency	1 millisecond	0.1 millisecond

Source of info: *Key Drivers and Research Challenges for 6G Ubiquitous Wireless Intelligence,* University of Oulu, Finland

At the same time, the 6G network will seamlessly connect the sky, the earth, and the sea, while the Holopresence system allows images of people and objects in the distance to be seen in a room with realistic, full-motion, and real-time images, coupled with real-time audio communication, it is comparable to reality. These enable coverage of smart cities to expand to the suburbs and achieve global localisation, that is, people can enjoy the convenience of global living and communication while living far away from the metropolitan area.

Among them, internet-led or knowledge-based work will benefit from the development. With the changes in population distribution and aspirations, the authority of urban management must consider the effect of these new changes when planning housing, water supply infrastructure, community facilities, and public transportation.

6G gathers massive amount of data, therefore, the authority needs the assistance of advanced city planning tools, such as a visualised digital map software geographic information system (GIS) to handle the information. GIS works with AI, covering from the ground, including indoor and outdoor data, to the sky, the earth, and the sea. Currently, it has already used satellite imagery to estimate population, measure the ocean, predict the amount of global renewable energy and water resources, and more. It is expected that GIS will play an even more important role in the smart future led by 6G.

Summary

Hong Kong has always been ahead of mainland cities in the global smart city rankings. However, in the post-epidemic era, Shenzhen has adopted advanced technology to fight the epidemic and Shanghai has accelerated the development of its smart city. Hong Kong needs to speed up by using advanced technology more actively to strengthen its leading smart city position.

Maps are valuable in various applications

02

Spatial data is the foundation for the development of a smart city. Through GIS, scattered data are integrated to effectively improve the city's competitiveness, so that "a map is worth more than a thousand words".

2.1 What are the implications when the topic of smart city appears in a HKDSE paper?

In the Liberal Studies Paper 2 of the Hong Kong Diploma of Secondary Education Examination (HKDSE) in 2020, out of the three questions, there was one about smart city development, which made me excited. Why? Being selected as an examination question means that 'smart city' has become a topic of significance and great interest in Hong Kong.

Why smart city?

What is a smart city? Although there are various definitions, they are generally based on using information technology to achieve the goal of improving a city's increasingly serious problems of living, employment, environment, and an ageing population, and achieving greater and more sustainable benefits. The United Nations predicts that by 2050, nearly 70% of the world's population will live in cities, while the percentage today is 55%. The future trend of rural residents moving into cities will mainly occur in Asia and Africa. With booming population growth, there will be another 2.5 billion people added to urban areas by 2050. This is why the smart city has become an urgent topic to be pushed in many advanced and developing regions.

Let us go back to the Liberal Studies question of the HKDSE. It quotes two examples: the award-winning work of the U.S. Department of Transportation's 2017 Smart City Challenge, and Indian environmentalists'

"Development of a smart city requires the participation of the general public to achieve consensus with the aim of benefiting all people."

Amager Resource Centre, Copenhagen's cutting-edge incineration combines a dry ski slope, outdoor climbing walls and running trails.

questioning whether a smart city would only benefit the wealthy, and asks about the possible impact of smart city development on energy use and how to establish a sustainable society.

There are numerous examples of energy sustainability such as autonomous vehicles which can save up to 90% of fuel, according to the U.S. Department of Energy estimates. Simultaneously, European countries are constructing cycling tracks and actively promoting bike use to reduce carbon emissions.

Denmark: sustainable development with fun

Denmark is even more aggressive in its sustainability. Copenhagen, the capital, has set a goal to achieve zero carbon emissions by 2025. By that time, 75% of the city's travel will be by bicycle, walking or public transportation. It is also a leader in turning waste into energy. Amager Resource Centre (Arc), Copenhagen's cutting-edge waste-to-energy power plant combines hedonism with sustainable development. When everyone in the world opposes locating an incinerator within their neighbourhood, this three-year-old building is only 5 km away from the Town Hall Square (approximately the distance from Central to North Point). It also serves the dual purpose of a dry ski slope, with a combination of outdoor climbing walls and running trails. The incinerator provides heating for 160,000 households and electricity for 50,000 households in the city. The efficiency of power generation is double that of the previous one, and sulphur dioxide emission is reduced by 99.5%.

However, even with cutting-edge technology, it would be difficult to achieve these results without the endorsement and participation of the public. For example, the major reason for the high energy efficiency of Denmark's incinerator is its strict garbage classification with taxation to discourage landfill waste – from 1987 to 2018, its landfill tax per tonne of waste gradually increased almost 12 times over in 31 years.

Co-creation a must

What about Hong Kong? We don't even have waste classification. What's more, the household solid waste in Hong Kong is currently the wettest in the world, more than 70% of food waste is classified as "ultra-wet", which is higher than 50% in Japan and South Korea and 30% in Europe. Therefore, it may not be that efficient to generate energy from waste in Hong Kong.

The major prerequisite for the development of a smart city is that all people participate through brainstorming and discussions to reach consensus, otherwise it will be difficult to achieve the ultimate goal of benefiting the whole society. That is the reason why I founded the non-governmental organisation Smart City Consortium (SCC) in 2016 to gather industry professionals and to provide expert advice for the government to develop Hong Kong as a smart city.

Input from experts for smart city development

Before the launch of the *Smart City Blueprint for Hong Kong 2.0*, the SCC held discussion sessions with various industry experts and scholars and met with the Hong Kong General Chamber of Commerce and the Jockey Club Design Institute for Social Innovation of the Hong Kong Polytechnic University to consult them on the future realisation of Hong Kong as a smart city. A proposal which incorporated their input was submitted to the Innovation and Technology Bureau afterwards.

The proposal covers six major areas: Smart Mobility, Smart Living, Smart Environment, Smart People, Smart Government and Smart Economy. Among them, there are many practical measures that are relevant to people's livelihood, such as smart solutions to deal with the "double-ageing" of an ageing population and ageing buildings; using information technology to improve public toilet management; applying sensing devices to analyse air pollution to identify effective solutions; strengthening digital infrastructure to enhance the competitiveness of SMEs; exporting smart city experience to other countries, and more.

Are there any other smart solutions? Certainly! The smart city cannot be built overnight, it is important that the public appreciates the benefits brought by smart city and then co-create more applications. Moving forward, I hope that Liberal Studies will include smart city in key learning units and as an independent topic for studying, so that we can engage more students ready for developing future applications. By doing so, we could work together to promote the development of a more creative and practical smart city.

2.2 The epidemic pushes the world to change

The Covid-19 epidemic has been raging around the world for more than two years. The situation is disturbing. However, it also brings many initiatives to change the world. Here are some interesting examples:

Artificial Intelligence (AI)

BlueDot, a Canadian startup used AI's natural language processing (NLP) and machine learning (ML) to screen worldwide news reports in 65 languages, plus airline booking data and animal and plant disease reports, and detected "unusual pneumonia" cases at the end of 2020, nine days before the World Health Organization (WHO) released its statement on the disease.

Kamran Khan, who was originally an infectious disease expert in Toronto, founded this AI platform as a result of the 2003 SARS epidemic. He witnessed the tremendous lethality of infectious diseases and hoped to avoid the recurrence of a similar incident.

Amid this epidemic, AI has been widely deployed. For example, some scientists in Shanghai have used deep learning (DL) to examine the CT scans of lungs. Combined with review by human experts, the diagnosing time has been greatly reduced from several hours in the past to four minutes. Since extracting saliva samples from deep in the throat causes great discomfort,

> *"The government should set up a joint operation platform for consolidating information from various departments and display the information on a large screen, so that the commander can fully grasp the situations for resource allocation."*

researchers are experimenting with other less invasive methods, such as using AI to detect abnormal breathing sounds.

In the early years, everyone said that data was like petroleum. In recent years, the analogy has been changed to sunlight and air. AI lives on data. When facing the global epidemic, the Johns Hopkins University (JHU) of the United States first linked the data of cases from various places for download on its Interactive Map Dashboard. The Allen Institute published 29,000 medical papers, including those in peer-reviewed medical science journals. By doing so, they hope to gather insights and reach breakthrough discoveries related to the epidemic as soon as possible. The scientific research community has always been fiercely competitive, therefore their willingness to share precious data implies that this epidemic is an opportunity to bring about change.

Similarly, if Hong Kong's public and private organisations, such as mobile network operators and the Octopus company, can share anonymous data on confirmed patients with researchers for free, I believe there will be chances to achieve breakthroughs for the local smart healthcare industry.

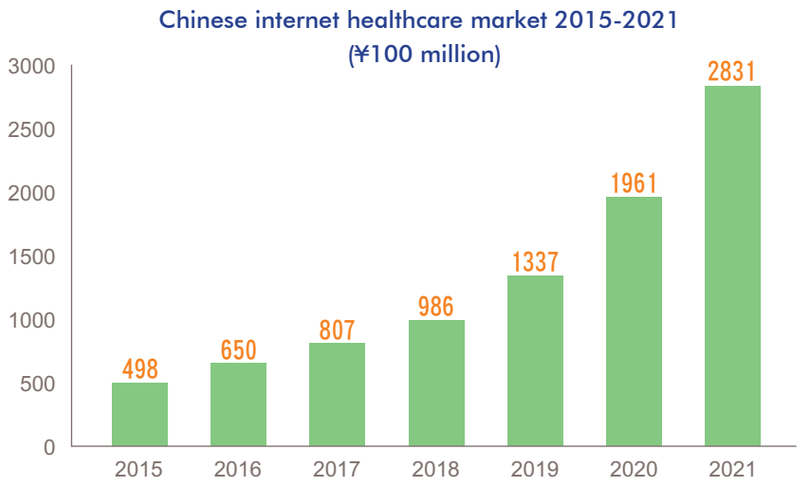
Telemedicine

This epidemic also brings remote medical consultations (or telemedicine) into the limelight. In a densely populated place like Hong Kong, there is always a clinic nearby. Furthermore, since there is a lack of official guidelines on telemedicine, many doctors have shown hesitation in joining.

Fortunately, the Medical Council of Hong Kong announced the *Ethical Guidelines on Practice of Telemedicine* in December 2020, clarifying the grey areas of the service. It coincides with the current situation that fewer people visit clinics in order to reduce the risk of being infected which has led to a considerable increase in the number of online consultations. According to a local medical service and information technology platform, DoctorNow NEEDS, the number of online consultations on their platform has increased "exponentially" since the outbreak. For example, people asked for professional opinions from their platform, so as to decide whether to postpone hospitalisation. Although the current number of diagnoses and treatments is not large, with the increase in the number of doctors providing online services and more insurance companies introducing related compensation schemes, I believe that telemedicine will eventually become the local norm.

In the Mainland, telemedicine has also seen an explosive increase during the epidemic. According to JD Health, a subsidiary of JD.com, a mainland online retail group, since early 2020, their monthly consultation usage has reached 2 million, 10 times the normal level. As quoted by *The Economist,* the head of JD Health previously expected to achieve this volume within five years of development. But, owing to the epidemic, it was achieved almost instantly. As for the size of the market, analysts from Analysys, a consultancy

Telemedicine has seen an explosive increase during the Covid-19 epidemic.



Source of info: Askci.com

in the Mainland, estimated that it would be approximately RMB 158 billion before the outbreak, but it jumped to almost RMB 200 billion in early 2020, an increase of more than 25%.

Telemedicine has always been regarded as an important alternative measure to cope with ageing populations and alleviate medical burdens. There have been many discussions on its development without much progress in the past, but it is expected to flourish after in the near future.

Electronic map widely used

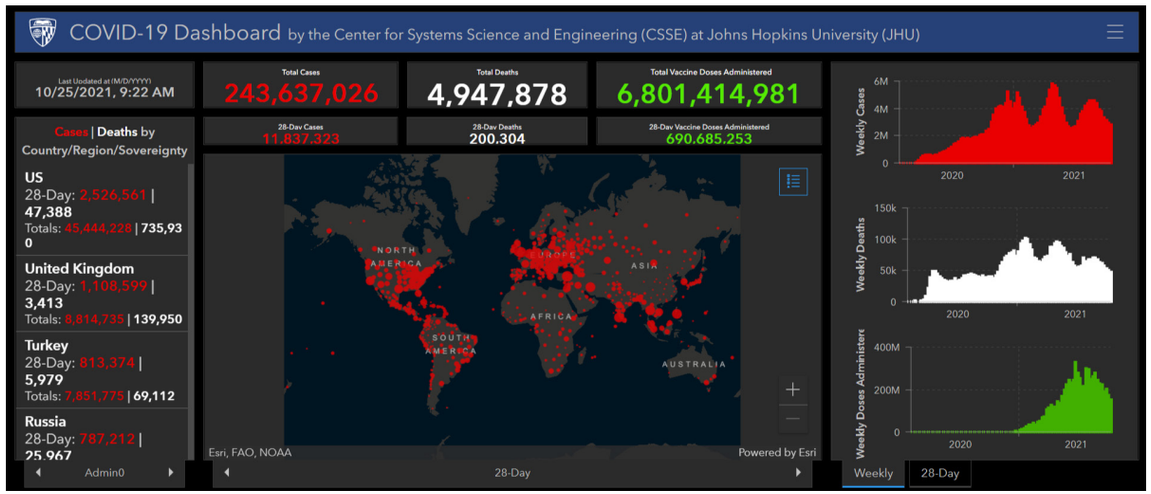
As a map lover, I have never seen any time like this with maps playing a major role in addressing a pressing social issue, the epidemic. Interactive map dashboards are used by the JHU, the WHO and over 60 countries and economies as of early 2020, such as the European Union, and local governments, including Hong Kong, the Mainland, Singapore, Japan, South Korea, the U.S., Canada, the United Kingdom, Germany, Italy and even Congo in Africa to manage the current situation.

In fact, the science enabling these dashboards is the geographic information system (GIS) which aggregates, organises, analyses, and visualises data according to geographic locations. I have been working in this field for more than 20 years and am honoured to partner with volunteers from the Smart City Consortium to set up an official information platform for Hong Kong. With the joint effort of the government's various bureaux and departments, we integrated open data and completed the platform in just a few days. The dashboard provides a clear picture of the epidemic's development and helps clear up rumours and confusing messages about the epidemic.

As a planning tool for modern cities, GIS can go far beyond these applications.

Just as Bill Gates publicly warned a few years ago, it is not nuclear war but infectious diseases that would bring the greatest disaster to the world. In the past two decades, the world has experienced SARS, avian influenza (H5N1), Ebola, Middle East respiratory syndrome, related coronaviruses, and more. Therefore, the WHO has already urged governments to prepare pandemic influenza response plans and be ready at all times.

Johns Hopkins University established the world's first interactive map dashboard on Covid-19 in early 2020.



Source of info: Center for Systems Science and Engineering at John Hopkins University

GIS for the next outbreak

With today's rapidly changing epidemic situation, various government departments need to coordinate anti-epidemic actions, GIS can contribute in this regard. For example, to facilitate internal communication among various departments, the government should set up a central information platform also known as the Common Operational Picture.

This central information platform also serves as a command centre, allowing the commander to fully grasp the situation and allocate resources as needed. In this way, various departments can integrate the latest information and display the emergency situation on the big screen for the commander to decide the corresponding actions. These departments include: the Centre for Health Protection and the Hospital Authority (confirmed cases, suspected cases, quarantine), the Immigration Department (number of local, mainland and other residents entering Hong Kong through the three ports of Shenzhen Bay, Airport, Hong Kong-Zhuhai-Macao Bridge), the Information Services Department (refute rumours), the Food and Environmental Hygiene Department (food supply, masks and supplies of daily essentials), the Education Bureau (school arrangements), the Leisure and Cultural Services Department (closing facilities), etc.

For more than 20 years ago, Hong Kong took the lead in adopting GIS for planning in Asia. I hope that we can continue to contribute to the forefront of mitigating the impact from infectious diseases on communities.

A recent article, an imagined letter from Covid-19 to humans written by Kristin Flyntz in early 2020, reminds everyone to slow down with classes closed, no more gatherings and shopping possible, we should reflect on what

has gone wrong on the earth as seen in the health of trees, the conditions of rivers, and severe weather. Will these reflections ultimately change humanity? Maybe this provides the impetus to change the world.

The local Covid-19 interactive map dashboard facilitates public understanding of the changing situation at a glance.

Source of info: Hong Kong SAR Government

2.3 Geospatial information helps epidemic research

To enable a more effective tracing of Covid-19 infections, the government has awarded funding to the Hong Kong Polytechnic University for relevant research, including the use of the geographic information system (GIS) to establish a coronavirus gene database. Through whole-genome sequencing, together with the analysis of the symptoms' onset time, location and travel record, the researchers hope to find the source of the epidemic outbreak.

Location information forms a large part of the big data which consulting firm McKinsey highlighted as the next frontier for innovation. No wonder, it is more and more common to study infectious diseases such as Covid-19 using geospatial data. For example:

1) Time and Place

A group of Mainland researchers analysed more than 1,000 confirmed cases as early as February 2020, including the patients' age, gender, symptoms and their spatiotemporal characteristics, i.e., tracking the path of the rapid spread of the disease throughout Mainland China, the distribution of patients by province, and the history of direct contact with wildlife.

Later, researchers in the United States, Iran, South Korea, Brazil, Israel, Italy, Spain, India, and Pakistan adopted this approach to study their own situations.

“Geospatial data is growing rapidly. It becomes more common to use geospatial data to study communicable diseases such as the Covid-19 disease.”

2) Healthcare, society, and geography

- The more nurses, the lower the mortality rate? According to a global study, this hypothesis is confirmed.

- Can friendship established in the virtual world lead to more cases of epidemic in reality? A study in the U.S. compared two Covid-19 heavily hit places, an American county and an Italian municipality, with other cities to see if the Facebook friendship links have a correlation with the infections, assuming that such friendships can lead to a higher probability of physical interaction. It was found that those listed as friends on Facebook had a greater chance of mutual infection, which helps epidemiologists predict the spread of infectious diseases.

- Under the recent outbreak in Melbourne, Australia, there was a study of the accessibility of health services in relation to the distance between a local community with a concentration of elderly and the hospital and pharmacy. This study has reference value for other countries and can help them to determine the medical needs of remote communities.

- Which of the following factors are related to the epidemic? Distance from the ocean, latitude, population density, air pollution level, or weather changes in the past few months, including temperature, humidity, wind speed, number of rainy days, etc. A study of 55 Italian cities concluded that the spread of the virus may accelerate in places with poor air quality, slow wind speed and further distance from the ocean.

3) Forecast distribution

An analysis of wastewater can help detect the location of dormant patients. Although it cannot replace personal testing, it is a quick, cost-effective and non-invasive method to trace the spread of the virus and the number of patients within an area. This method has been used in the national surveillance of hepatitis A in the past. Now, studies in the Netherlands, the U.S., and Australia have confirmed that it can also be used for the Covid-19 epidemic.

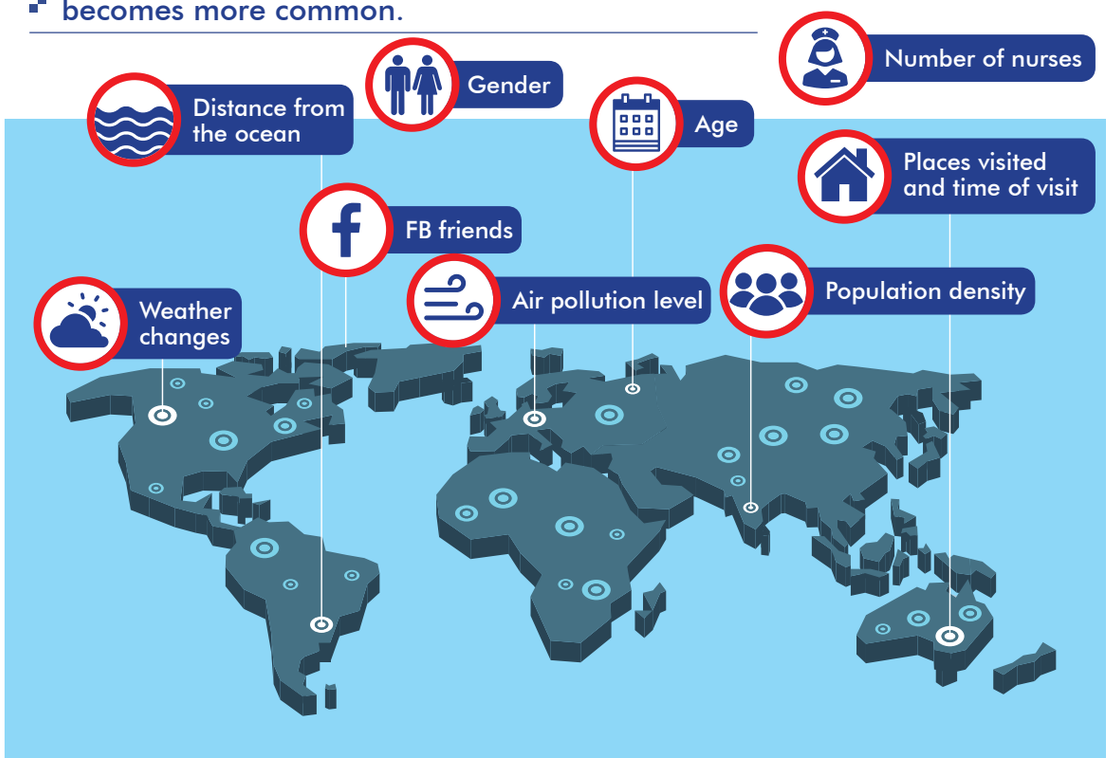
Take Germany as an example. It has the highest testing capability among European countries with about 100,000 clinical assays per day. However, it would take three months to complete the testing of all its 83 million citizens just once, with the cost of the assay reagents estimated at US$1.25 billion. However, if they start with their 10,000 wastewater treatment plants, each test kit costs US$15 on average, the total cost is only US$145,000, and the results can be obtained within one or two days.

In Hong Kong, the "Innovative Sewage Testing Tool for SARS-CoV-2", which won the Gold Medal at the Special Edition 2021 Inventions Geneva Evaluation Days and was conducted by an interdisciplinary team from the University of Hong Kong, for sewage monitoring has prompted the government to carry out compulsory testing operations on more than 230

buildings and detected positive sewage test results since the end of 2020. Over 50 confirmed cases were subsequently identified, many of which were detected before any infections were found or confirmed in the building. The HKU team also successfully found the Delta variant in a sewage sample collected in June 2021.

If the sewage of every building in the area can be tested using this method, buildings without carriers can be excluded, which may ease residents' worries, while the authority can allocate personal testing resources more effectively.

Using geospatial data to study infectious diseases becomes more common.



2.4 Public-private partnership facilitates smart city development

Smart city development should be a result from the co-creation of various stakeholders in society. That's also the theme of a survey report published by the Smart City Consortium (SCC), which I founded and where I serve as the Honorary President. The report reviews cooperation between the public and private organisations in Hong Kong and examines how effective it is so far.

The survey *Future Hong Kong 2030* is the joint effort of several organisations including KPMG, CLP, Cyberport, and more. It has interviewed 430 senior executives from corporate enterprises, small-and-medium businesses, startups, government departments, not-for-profit organisations, and academia.

In the first *Smart City Blueprint for Hong Kong* released in 2017, the government addressed the issue of the public-private partnership. The blueprint, outlining smart city development over the next five years, mentions: "Smart city calls for close collaboration among the public sector, private sector, academia and citizens over the whole cycle of implementation… Public-private partnership (PPP) is one of the popular implementation models in other jurisdictions for smart city development. We will consider appropriate implementation model, including PPP, for individual smart city initiatives…A dedicated Smart City Office will be set up under the Innovation and Technology Bureau to coordinate smart city projects across different government departments and agencies in the public and private sector and

> *"When selecting private companies to participate in the construction of the smart city, the government should focus on value for money, and not the one with the lowest bid."*

monitor project progress and effectiveness." These were really new and exciting ideas at the time.

However, according to the 430 senior executives interviewed, most mentioned a lack of opportunity for partnerships with the government though they had "a strong willingness" to do so. Only a few were actually working with the government on smart city initiatives. The executives surveyed wished the government to focus on "value for money" rather than "the lowest bid wins". In this way, companies would have the chance to provide high-quality services for the public and earn a reasonable income. I strongly agree with the view.

At the same time, the government has mentioned on many occasions about promoting local innovation and technology, it should set an example by personally taking part and adopting more local technological solutions.

For example, the idea of using sensors to improve the maintenance of public toilets, which has continuously been criticised, is an idea I have already supported in the past. By using indoor radar sensors, the people in charge can monitor the supply of toilet paper, the vacancy of toilet compartments, whether someone has fallen inside, and also measure the level of urea so as to ensure a timely handling of the issue. In addition, the government can strengthen communication with the general public through the release of information on an interactive map dashboard, including various economic revitalisation and relief measures under the epidemic, the number of companies and employees benefitting from the wage subsidy and rental reduction, the number of temporary employment positions, and the effectiveness of different employment schemes. What's more, the distribution of Covid-19 vaccines in target groups and the number of vaccines allocated to each target group, the daily number of those vaccinated, and the cases of abnormalities after the vaccinations should also be listed, so as to let the public be aware of the latest developments to reduce suspicion or speculation.

In fact, the success of a smart city relies not only on clear visions and comprehensive planning, but also on the careful implementation of various technical measures. Private organisations are often more able to keep up with the pace of technology. Therefore, adopting a flexible and innovative cooperation model with private industry can facilitate the effective construction of a smart city.

2.5 Connecting geo-locations to unlock data value

Many countries including the United Kingdom, Canada, and Japan are facing the problems of an ageing population and declining productivity, the smart city has become their best solution.

The research institute IDC observed that among the five smart city projects that every nation focuses on, three are data related, namely data use, digital trust, and data-driven public safety, and these are all closely related.

Let's talk about data use first. The intelligence of smart cities is largely based on massive data. However, it is not easy to integrate fragmented data to unlock their values. For example, for the same location, different sources can have different ways of presenting the same event, which makes it difficult to link the data and reveal useful information, let alone insight. Therefore, IDC predicts that 30% of smart city projects will fail due to unclear key performance indicators (KPI), making it difficult to assess and consequently harder to convince clients to allocate funds.

In other words, how to produce measureable results from data is the most critical issue.

William Priest, Chief Executive Officer of the Geospatial Commission in the U.K., shared his experience on how spatial data can drive the economy and

“The U.K. assigns unique numbers to things that have geographic locations, just like ID card numbers, turning fragmented data into useful information.”

government operations. The Commission, part of the Cabinet Office, aims to open spatial data for free to promote the economy and efficiency. Though the Commission was established only four years ago, it has been very active during this period and has achieved significant results. It is quite impressive.

The nation is facing the problem of ageing infrastructure, while the demand for services has continued to increase, ranging from identifying housing development plots, flood prediction to public transport efficiency. There is an urgent need to use the existing resources more efficiently but how can spatial data solve these problems?

Through digital spatial data workflow, the land conveyance service was shortened from 90 days to a few hours. A common spatial database can benefit public utilities, as well as the construction and telecommunications industry. At the same time, the authority estimates that if they could maintain a detailed record on the exact location of underground infrastructure, thereby avoiding the crisscrossing of proposed pipes with existing facilities, project efficiency could be improved while minimising service interruptions. Ultimately, the government could have better planning, reducing the government's infrastructure expenditure by £4.6 billion (about HK$46 billion) annually.

How to do it? It relies on data. First, we should integrate the data; to facilitate the integration, it is crucial to connect with geographical locations.

In 2019, the Commission published the *Linked Identifiers Best Practice Guide*, which recommends that every geographical object in the nation, including buildings, waterways, and roads should have a unique identifier or code. Organisations can link these codes to the data in their hands, so that different objects at the same location, originally spreading across different datasets, can then be linked together. It saves time and makes it easier to get an exact overview of the information connected to a particular location. This simple and clever approach helps turn fragmented data into useful information for activities like managing a road network, or responding to an emergency.

In addition, Mr. Priest also suggested a single platform for the convenience of data use.

As for Hong Kong, fortunately, we are moving in this direction of building a single platform, called common spatial data infrastructure (CSDI). However, in terms of connecting data from all parties, especially connecting with geographical locations to facilitate the analysis and promotion of creative industries, we still have not moved forward. Therefore, I expect that the Innovation and Technology Bureau and the Development Bureau will join forces to make it happen so that we can really realise the value of data.

By doing so, I hope that Hong Kong will lay a solid foundation and continue to move forward on the road to smart city development.

2.6 A map is worth more than a thousand words

In the 19th century, London was attacked by an unknown infectious disease. While everyone thought that the contagion was airborne, Dr John Snow integrated the data related to the epidemic (later known as cholera), including locations, roads, water sources, and drew a map to identify the disease routes, which subsequently led to the discovery of the water-borne bacteria responsible for the outbreak. He explained his findings to the local government which led to the city successfully containing the outbreak.

Many social issues can be better understood through data. Apart from the Covid-19 epidemic, topics such as education, economic development, transportation, and health are all better understood with higher-quality data. We now have huge amounts of data; the Hong Kong government alone has opened more than 4,250 datasets. Therefore, many journalists have to master data analysis to be able to grasp the ins and outs of events. *The New York Times*, for example, held a series of internal data training programmes, which included data organisation using Excel spreadsheets.

However general readers can find it challenging to interpret complex tables and charts. On many occasions, they could understand better if data was presented on a map.

“To show data purely on a map may miss the story behind it; GIS analysis can provide insight to the story of an event.”

Map me a story

For example, BNR NieuwsRadio, a Dutch media outlet used data from a crowdsourcing app to map the highway locations of speed traps. The map shows which sections of the road where drivers are most likely to be caught for speeding, making drivers more alert.

More and more reporters make use of maps to tell their stories. Researchers at the University of Hamburg in Germany found that in the Data Journalism Awards held by the Global Editor Network (GEN) from 2013 to 2016, half of the 225 nominated projects used maps.

However, if maps are used merely as a tool to display data, journalists may miss the opportunity to discover the stories behind them. The data processing and analytical functions of geographic information systems (GIS) which organise layers of information into visualisations can reveal patterns, relationships, and situations.

For example, a primary election in Philadelphia City Council in the U.S. brought the surprise defeat of a council member who had held office for 27 years. You can map the results by voting district and see which parts of the district voted for the incumbent and which for her challenger, and then infer the causes, such as an increase in young voters and new immigrants.

But if you want to verify these guesses, you need to turn to GIS by pulling data such as demographic characteristics and property prices by voting district. In Philadelphia, you can see that the challenger attracted huge margins of support in wealthier areas with more expensive housing and higher-educated voters.

GIS can be widely applied, from tracking the epidemiology of public health during Covid-19, emergency rescue, country park management, flood forecasting, school placement allocation (for students who intend to study in a government/subsidised school, they need to show residential proof to qualify), and traffic management, to housing planning and online shopping services.

Careful, responsible use

While the waters can keep a boat afloat, they can also overturn it. In the U.S. presidential election in 2020, the media showed the Republican Party supporters in bright red on the map and the Democratic Party in blue, which made people mistakenly believe that Republicans were leading while the opposite was true. Betsy Mason, a journalist who studied geology, reminded her peers that readers are very prone to believe things that they see on maps, so media workers have to be careful, responsible, and understand that maps are “not just illustrations to break up the text.”

At the peak of the epidemic in Hong Kong, local newspapers used maps to show the location of Covid-19 cases in various districts. However, their mapping approach was traditional and static, and seldom uses advanced technology like GIS to analyse the spatial-temporal relationship, like showing the linkage between the infected groups and the demographic characteristics of certain areas within a particular period of time. As a GIS professional, I look forward to more exploration and trial applications of this innovative technology by media practitioners so that readers can easily understand the dynamics of the issue as presented.

2.7 Improving new town planning

In the *2021 Policy Address*, the development of a Northern Metropolis was proposed, suggesting the Northern Economic Belt to expand and integrate the new towns in Yuen Long, Tin Shui Wai, Fanling, and Sheung Shui, with a total area of 300 square kilometres. Together with the ones in Kwu Tung North New Development Area, Hung Shui Kiu / Ha Tsuen New Development Area, Yuen Long Industrial Estate Extension at Wang Chau, Liantang / Heung Yuen Wai Boundary Control Point, San Tin / Lok Ma Chau Development Node, and Tung Chung New Town Extension, we expect to have more new development areas over the upcoming decades.

These major projects will lay the foundation for Hong Kong's future as a smart city. Therefore, the authorities should learn from past lessons and avoid the previous mistakes.

City planning has long-term impact

Hong Kong has many successful experiences in the development of new towns. For example, Sha Tin and Tai Po have achieved a balance between urban construction and greening. At the same time, they incorporated industrial and commercial elements, as well as people's livelihoods to create employment opportunities. The rural areas have successfully evolved into today's mature communities. However, there are also cases of a lack of planning with Tuen Mun and Tin Shui Wai as examples. They have

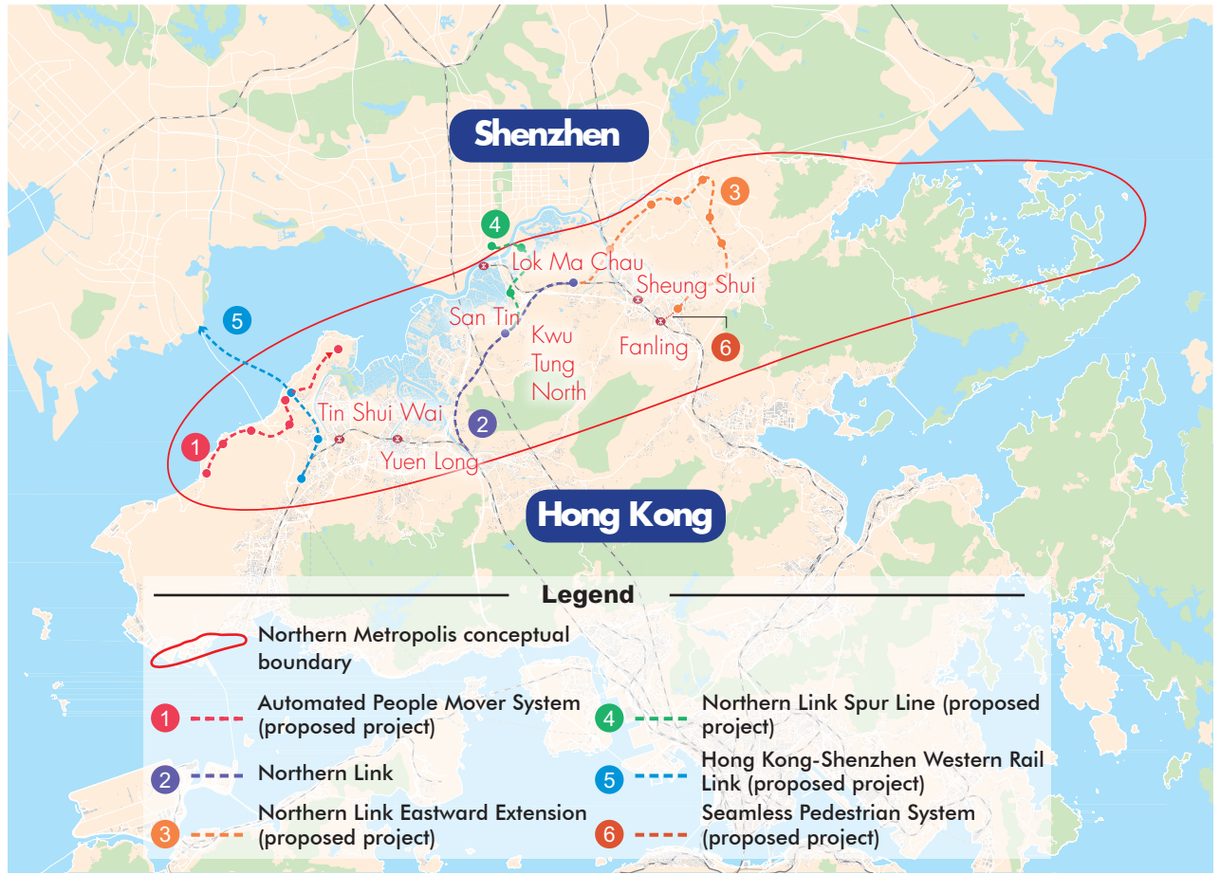
"GIS is strong at coordinating data from different sources, such as AI and BIM, as it helps decision making and team communication."

been criticised for single type of land use, and poor supporting facilities, especially in traffic design. Tin Shui Wai is described as "the city of sorrow" as residents are trapped in the town because of the poor transport provision.

Looking at the above two sets of examples, we can understand that comprehensive planning not only affects the well-being of residents, but also has a long-term impact. Advanced technology can anticipate problems, assist in finding solutions, and also promote communication with the general public for a smooth project execution.

In fact, the government has repeatedly used innovative technologies for infrastructure projects in recent years. For example, the Hong Kong Housing Authority has applied 3D reality capture technology in planning, design, and construction, which helps to facilitate the collection of data on development sites, saving manpower and energy. The Tung Chung East reclamation project has used more than 30 innovative technologies, including a digital twin, the internet of things, and a cloud system to monitor the daily operation of the construction sites.

For a healthy and sustainable development of new towns, the government should optimise the use of spatial information.



The *2021 Policy Address* proposed building a Northern Metropolis in the New Territories. The red circle in the picture above is the conceptual boundary of the Northern Metropolis.

Source of info: Hong Kong SAR government

Achieve greater impact with less effort

However, if the authorities can make good use of the geographic information system (GIS) already deployed, it will definitely achieve greater impact with less effort. The leading edge of GIS is its open system which is strong in aggregating, storing, and sharing various engineering-related data, including LiDAR for measuring distance and ranges, point cloud for producing 3D models, voxels for measuring and visualising ecological marine units, as well as low Earth orbit imagery, building information modelling (BIM), computer-aided design (CAD) drawing, real-time internet of things (IoT) and more, with no need for users to switch between different interfaces.

This centralised platform for gathering engineering and construction information is known as a common data environment (CDE) in the construction industry. It collects, manages and disseminates a variety of project-related information, facilitating collaboration between project team members, avoiding duplication and mistakes, and enabling the team to fully evaluate project results, as well as the impact on the surrounding environment and long-term benefits. It is a great help for decision-making.

GIS applications in large projects

GIS has been widely used in the construction industry and major projects due to its powerful analysis, data compatibility, and 3D display functions.

The Crossrail in London, branded the Elizabeth line, is one of the examples. The rail project is Europe's largest infrastructure project in recent years, costing £15 billion, it will start operating in the first half of 2022. Encompassing 42 km of tunnels and 10 new stations, the Crossrail will connect the suburbs with the city centre and the Heathrow Airport. One of the major issues of this big project is how to properly manage the huge amount of information up to 12TB, including 2 million CAD drawings and models, 8 million documents, 1 million assets, and 50 million GIS features. The inventory of assets is constantly growing with many programmes of work being carried out simultaneously.

The authority decided to use GIS to record and manage the complex and ever-changing asset list.

The scale of this project is huge, there are many construction sites, and many constraints which have to be considered, from monitoring the project progress to avoiding illegal occupation of the site. GIS is strong in data analysis, it is also an information platform that facilitates the integration of spatial data from different sources and various software to share among users. At the same time, the authority has established a suite of server-based, desktop, web, mobile and 3D GIS applications to effectively control costs, reduce project delays and overruns, and ensure network security. Its 3D visualisation capabilities make it easier to record the location of assets.

According to an article from the Chartered Institute of Logistics and Transport, the online application of GIS greatly reduces the time spent by employees in preparing reports by 80%. Regarding management, GIS also facilitates communication with an external audience.

3D visualisation enables better communication

Furthermore, the 3D map display function and the interactive map dashboard of GIS are handy tools for strengthening communication between the government and the general public, especially in promoting the public's understanding of land use.

Nowadays, transparent communication is important for building trust. One of the recent examples is the launch of an interactive map dashboard called "Coronavirus Disease (Covid-19) in HK" in early 2020 when there was much anxiety within the community. The map dashboard has enhanced the transparency of government efforts and has facilitated the public understanding of the changing situation at a glance, which can be calming. The effectiveness of GIS is well proven. As of end 2021, the map dashboard has attracted more than 58 million views. It is a successful case of government inter-departmental cooperation to convey information with the help of GIS.

Actually, the authority has already installed advanced software systems such as GIS, they should make the most out of the technology to reap more benefits.

Therefore, I hope that in the projects in the new development areas, the authority will actively adopt GIS to coordinate and assist internal and external communication, so that the plan can be implemented with more success.

2.8 Advanced technology facilitates better planning for new railway routes

The MTR Corporation Limited (MTR) has started the detailed planning and design of the Northern Link project in the New Territories. It includes constructing Kwu Tung (KTU) Station, and a 10.7-km-long railway link between the existing Kam Sheung Road Station of West Rail Line and KTU Station, with three intermediate stations at San Tin, Ngau Tam Mei and Au Tau. The entire line is expected to be completed by 2034.

With the Northern Link connecting the East Rail Line and the West Rail Line, a railway loop will be completed serving the New Territories and Kowloon, which can greatly improve the transport connectivity between the east and west of the New Territories. For example, it currently takes more than one hour to drive from Yuen Long to Kwu Tung during peak hours; after opening the three stations on the Northern Link, it will only take 12 minutes for a railway journey from Kam Sheung Road to Kwu Tung. Besides, the land along the Northern Link is expected to lead to the construction of more than 70,000 housing units.

40-minute living circles along the route

To plan and design a railway is a very complicated task, planning the route alone is challenging. First of all, the route should avoid cutting into major slopes to reduce the cost of construction, it should also not encroach into restricted areas such as country parks and military land. It is better to use the currently less populated area as land resumption would be much easier.

"When designing a railway line, apart from considering cost-effectiveness, it is also necessary to facilitate the nearby residents commute to work, to school, and bring convenience to their daily life."

At the same time, a well-designed railway has to enable residents along the line to go to work and school conveniently. According to several travel surveys conducted by the Transport Department in the past, the average journey by public transport took more than 40 minutes. Based on this, we can plan 40-minute living circles along the route, covering community facilities such as schools, shopping malls, wet markets, clinics, and leisure spaces, as well as employment opportunities in industrial and commercial buildings, to match the demographic characteristics of the future residents in the new public and private housing. Meanwhile, Kwu Tung, the last station on the line, can be connected to the East Rail Line via Lok Ma Chau where people of high-tech industries will be attracted after the completion of the Lok Ma Chau Loop in the future. How to cater for the needs of this segment should also be one of the requirements in planning.

It is the right time to deploy the electronic map software, geographic information system (GIS) for analysing and co-ordinating so many intricate data and needs.

- The new railway planning should include a 40-minute living circle along the route for the convenience of the residents.

US$1 Trillion asset management

In addition to routing, it is also crucial to manage the hard assets of the railway system, ensuring that the train service is on time, and dealing with the daily maintenance and emergency repairs, as well as taking care of passengers' increasing service requirements. For effective management, we can refer to New York's Metropolitan Transit Authority (MTA) which manages assets worth US$1 Trillion.

The MTA serves nearly 9 million bus and train passengers every day. The transportation system encompasses more than 600 miles of track, more than 12,000 buses and train cars, along with the stations, bridges, and tunnels, as well as sensors that collect data on track temperature, alignment, moisture, and other physical conditions. Many facilities have reached the age of 100, but the number of passengers continues to increase, from 960 million in 1975 to more than 1.7 billion in 2017 (the number of passengers of the MTR in Hong Kong was 2 billion in the same year). At the same time, the train service is 24 hours a day, repairs have to be undertaken in between trains.

The management believes that instead of making frequent repairs, it is better to take preventative and predictive measures, which are three or four times cheaper than urgent repairs when failure is imminent. Therefore, they use GIS to mobilise the team, accurately direct the labour to designated locations, and use virtual 3D maps, one of the GIS tools, to create a digital twin to simulate the impact of upcoming maintenance works, to see how tunnels, tracks, signals, and utility infrastructure would be affected. Then they can make adjustments to minimise disruption to the service.

I hope that the authority in Hong Kong can also use innovation and technology to deliver high quality railway services and build a liveable community for us.

New York City's transport authority uses GIS to manage its US$1 trn assets.

US$1 trn assets include	• over 600 miles of track • more than 12,000 buses and train cars • 24 hours a day of train service • stations, bridges and tunnels • sensors to collect data on track temperature, alignment, moisture
Number of passengers	1975: 0.96 bn 2017: 1.7 bn

Source of info: Esri

2.9 Intelligent road networks to perfect smart mobility

> *"The Transport Department should improve efficiency with intelligent road networks, and open data to facilitate startups to develop applications which enhance the convenience of commuters."*

The government aims to establish a one-stop data supermarket or common spatial data infrastructure (CSDI) by 2022; it will facilitate the sharing of geospatial data among government departments and enterprises. The Legislative Council Panel on Development published a discussion paper titled *Development of Common Spatial Data Infrastructure and 3D Digital Map* in 2019. In the discussion paper, the Development Bureau proposed setting up a new spatial data office to undertake the work of a web portal launch. Some questions about the functions of the office need to be addressed.

In the *Hong Kong Smart City Blueprint* announced in 2017, the first task is to tackle the problem of mobility, the Blueprint proposed some solutions, such as installing detectors at main roads, sensors inside vehicles, and smart traffic light systems that can detect pedestrians and vehicles at road intersections.

My first question is how can we effectively integrate all the kinds of data collected, and truly facilitate the sharing of data among government departments, public and private enterprises, as well as the general public.

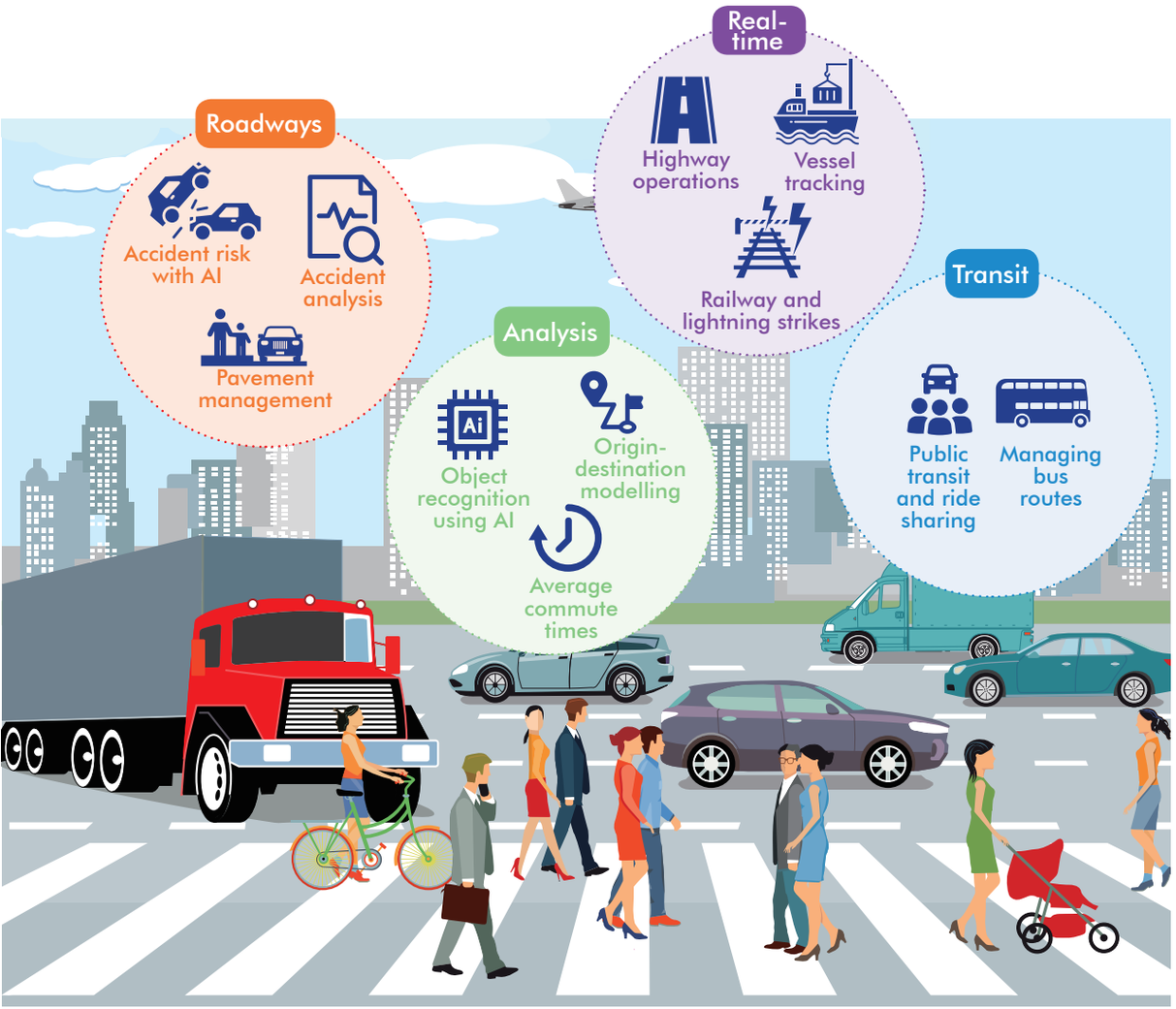
How to enable smart mobility

The Transport Department (TD), which manages the territory's traffic, has set up an advanced Intelligent Road Network (IRN) to link the road network's multiple data with geographic information and provide information such as the latest driving and turning restrictions at road intersections as well as roadside parking restrictions.

Multiple layers of information from an IRN can be shown, for example, a road with 50% of the total length has double white lines where overtaking is not allowed; 10% of the total length does not allow U turn, 30% allows turning left, 40% allows turning right; 30% of the roads are toll-free, while the rest are toll roads. This information in conjunction with traffic flow, accidents and public transport service updates form a dynamic IRN. It is not only useful for internal reference and applications, but also beneficial for the private sector, ranging from telecom companies, fleet and cargo operators, logistics and information technology organisations, which develop smart mobility applications such as car navigation, and fleet management systems, to personalised information services for the convenience of the general public.

At present, IRN is not deployed comprehensively within the TD, most applications still use simple maps or image maps. It is difficult for the authority to integrate all the information on a single platform for planning

GIS enables the management of multiple layers of dynamic information.



and management, thus, it is hard for the authority to keep up with the pace of the digital age.

Open data for public applications

TD should also strengthen the opening of road data to ensure everything is readily available in CSDI, so that developers can develop services for the convenience of the public, and road data can be combined with other public data to generate new information.

In this aspect, Auckland Transport of New Zealand and Highways England of the United Kingdom are the fore-runners. For example, the Auckland Transport Open GIS Data website combines information of public transport (buses, trains, ferries), road conditions (diversions, road works), parking spaces, cycling tracks and walkways, facilitating mobility planning.

May I suggest the Development Bureau take the initiative to coordinate and cooperate with TD to ensure that useful spatial data can be shared among government departments and other related parties? In the longer run, the potential of a CSDI portal could be fully realised and the value of spatial data will be unleashed.

Through the above measures, I hope that we can perfect smart mobility, promote innovation, and drive the development of the local digital economy.

2.10 Planning clean energy with advanced technologies

CLP Holdings Limited (CLP) announced that its wholly-owned subsidiary EnergyAustralia will build Australia's first net zero emissions hydrogen and gas capable power plant, helping to provide a reliable, clean and affordable electricity supply. The power plant will be in operation within a few years; this news makes me envious.

Hong Kong has been discussing clean energy with zero carbon emissions for many years. For example, Hongkong Electric spent ten million dollars in the early years to build a wind turbine on Lamma Island, while CLP has also studied the development of an offshore wind farm of up to 200 MW in the south-eastern waters. In recent years, the technologies, used to be expensive and not economical, have improved and become more mature.

The International Energy Agency predicts that the two renewable energy sources, wind and solar, will surpass gas and coal by 2024 and become the largest source of power generation, providing almost one-third of the world's electricity. The strong growth of renewable energy is driven by the decrease of cost in recent years. According to the International Renewable Energy Agency, solar photovoltaics (PV) has become a mainstay of low-carbon sustainable energy strategies, with the cost of electricity generated by PV plants declining by 77% between 2010 and 2018.

"The investment in clean energy is huge. GIS has been broadly deployed in the site selection, construction, and business development of clean energy."

Having said that, we are talking about an investment of 100 million dollars in these infrastructure projects. A windmill for power generation usually has a service life of 30 years only. Therefore, precise planning is required, that's why many companies use geographic information systems (GIS) to help planning.

One example is Renewable Energy Systems (RES), which has a service record of nearly 40 years and has been operating in Europe, North America, and Australia. In the past it mostly engaged in wind energy projects because of relatively low costs. As the cost of solar technology has dropped sharply recently, the situation has changed. To conclude whether solar and wind energy projects are cost-effective, the company needs to consider hardware, and most importantly the selection of the site, including elevation, slope, wind speed, waves, currents, soil composition, bedrock depth, ports, harbours, borders, existing infrastructure, shipping routes, and the cost of energy, as well as weather and historical data of seabed changes, and more, so as to accurately calculate the cost. Due to the various types of information involved, RES not only uses GIS for analysis, but also uses it to explore potential locations.

Moreover, Mainstream Renewable Power in Ireland uses GIS to build a complex forecasting model and create a 3D time-sequenced map of the seabed, showing possible future changes, in order to understand how climate change and ocean currents will affect the chosen development site in the future.

Equinor, a Norwegian oil and gas supplier, also one of the world's 2,000 largest public companies ranked by Forbes, enables its employees to experience the convenience of GIS interactive maps in works from engineering to business development. In the past they had to work with the mapping department to prepare reports or query map data. Currently, they can search for the information on their own through the interactive map using a computer, which improves efficiency and makes data-based decision-making more powerful.

2021 marked the 120th anniversary of CLP, I hope that the company can use advanced technologies such as GIS to introduce sustainable green energy to Hong Kong, so that we can also enjoy reliable, clean, and affordable electricity.

Off-shore wind farms are expected to become one of the largest sources of power generation in the future.

2.11 Addressing water shortages

In Hong Kong, we can have clean water by just turning on the tap, but this is not necessarily the case in many other places.

At present, 700 million people in the world don't have access to enough clean water. The number is expected to increase to 1.8 billion people within the next 10 years. The volume of salt water on earth is about 50 times more than fresh water. People may naturally think of turning sea water into drinking water. Hong Kong used such a measure in the past, but the cost was far too high.

In 2019, the *MIT Technology Review* in the United States selected the 10 Big Global Challenges Technology Could Solve, one of which is Israel's desalination technology. The world's largest seawater desalination plant is located at the outskirts of Tel Aviv, it supplies water to 20 % of the country's nearly 9 million population. In future, when additional plants will be running, 50 % of the country's water is expected to come from desalination. This plant uses a conventional desalination technology called reverse osmosis, together with new types of membrane technology, to enhance energy efficiency.

Singaporean way

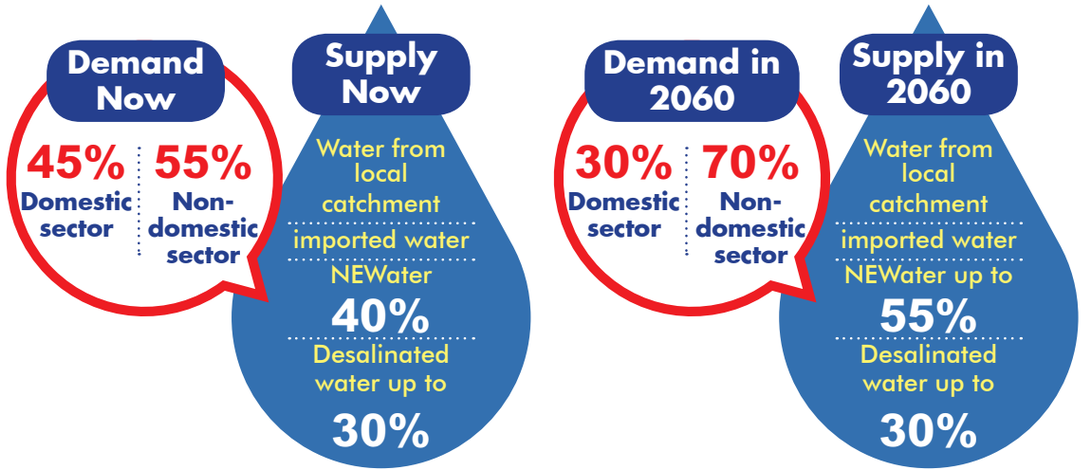
Singapore also has a water supply problem. The country consumes 430 million gallons of water a day (about 60% of Hong Kong's water consumption). With population growth and economic development, it is expected that the demand for water could almost double by 2060. There are three solutions: (1) construct more reservoirs to collect every drop of rainwater; (2) reuse household, industrial and commercial used water repeatedly through five water recycling plants, which supply 40% of the country's water, aiming for 55% in future; (3) seawater desalination supplies 30% of the water consumption.

> *"The Water Supplies Department is the first government department to use GIS to manage its assets of over 8,000 km of fresh water and sea water mains underground, setting a precedent for others."*

Singapore aims to become a global hydro hub, the country is actively marketing this hybrid water management solution to other places. Since 2006, it has invested S$670 million (about HK$3.9 billion) to foster the associated technologies.

At present, Singapore has 180 water companies and more than 20 research centres promoting the ecological development of the water industry. It is a win-win approach to address the global crisis while looking for business opportunities for itself.

Singapore reuses its household, industrial and commercially used water to meet their needs.



Source of info: Public Utilities Board, Singapore

What about Hong Kong? In the past, we also had a water shortage problem. Fortunately, we can obtain water from the Dongjiang of China. However, we also face many challenges, such as the rapid expansion of the city, and the deterioration of more than 8,000 km of underground fresh and salt water pipes. Technology could be a help in such cases.

Hong Kong led the use of advanced tech 20 years ago

Before the handover of Hong Kong, the Water Supplies Department (WSD) had taken the lead in using the advanced geographic information system (GIS)

The Water Supplies Department had taken the lead in using an advanced geographic information system before 1997.

Consumption (in million cubic metres)

Fresh Water	2019/20	2020/21
Annual Consumption	998.30	1 033.81
Daily Average Consumption	2.73	2.83
Highest Daily Consumption	2.93	3.05
Sea Water	**2019/20**	**2020/21**
Annual Consumption	310.27	317.93
Daily Average Consumption	0.85	0.87

Source of info: Water Supplies Department, HKSAR

to enhance its Digital Mapping System for the water main network, it was a forerunner among the government departments at the time. GIS is used to collect, combine, and process spatial data on the water supply network and data from field trips. The information is not only for water supply purposes, but also for collaboration with other government departments and public organisations.

With the advancement of technology, the public's expectation has also increased. The WSD introduced the Water Intelligent Network (WIN), and once commencing operation, the water pipe leakage rate is expected to drop from 15% at present to 10%.

The WSD's efforts have recently been recognised by the Leading Utilities of the World (LUOW), a leading global network of the world's most successful and innovative water and wastewater utilities. Earlier, Chau Sai Wai, Deputy Director of WSD, presented their innovation works in energy efficiency, information technology, and intelligent water networks, as well as water treatment and quality, at the Singapore International Water Week 2018. The WSD was awarded the LUOW membership certificate.

I have had the privilege of participating in the establishment of the Digital Mapping System since 1996, witnessing the over 100-year department's constant strive for self-improvement. I hope that the department will continue to use innovative approaches and smart technology to enable Hong Kong people to enjoy a quality living style brought by the smart city.

2.12 Population census witnesses technological progress

In mid-2021, the Hong Kong government conducted a population census in which a variety of information from basic data such as date of birth and gender to a broad range of demographic, socio-economic, and housing characteristics were collected.

The Hong Kong population census has witnessed technological progress in the last two decades. But can we go one step further to make the most out of the technology?

The census consists of work to connect people with places, so an accurate and up-to-date map is a prerequisite. As science and technology evolve, the arduous work of census taking also keeps up with the times. For example, in the 2001 Population Census, the digital mapping system (DMS) was used for the first time to support the work.

From paper to digital

In the past, the Census and Statistics Department could only store map data on paper, and manually maintain and update them for making maps. These processes included photocopying, cutting and pasting, and pencil marks on paper. In addition, these labour-intensive and time-consuming processes must be repeated each time the base maps from the Lands Department were updated.

"GIS greatly supports the work of census takers. It can determine the location of households and calculate the distance between them, it also allows the field workers to enter data in mobile devices."

Electronic maps with geographic data can improve efficiency for the Census.

The DMS that uses the global positioning system (GPS) and the geographic information system (GIS) was specially developed for the 2001 Census. The authority provided approximately 100,000 electronic maps with geographic data for the Census, which was convenient for the temporary field workers as it helped them locate the household of their assigned interviews. Electronic maps can also be used to calculate the distance between locations, which facilitates work allocation by calculating the workload and understanding the progress of fieldwork.

In recent years, DMS has been continuously improved and enhanced, including being able to be used on mobile devices. Updated building locations, photos, and sketches, as well as real-time input of collected data can be uploaded to the system, increasing work flexibility.

Advanced technology saves manpower

Simply put, technology has improved efficiency. Although the population has increased from 6.71 million in 2001 to 7.47 million over the past 20 years, and there are more households to be surveyed, only 18,000 temporary field workers are required in 2021 in contrast with 23,000 workers hired in 2001 when digital maps were firstly introduced.

Many countries have also conducted population censuses in the past two years, one of them is the United States. The country has carried out its decennial population census since 1790 and has gained a lot of experience, especially in using geographic information to optimise their work, which was also demonstrated in the census in 2020.

One of the challenges to address is verification. There can be big changes in 10 years. How to ensure accuracy of address data? With satellite imagery,

the authority was able to verify 65% of the addresses on desk, and only 35% needed to be verified in the field. Therefore, manpower can be drastically reduced from 150,000 in 2010 to 40,000 in 2020. In addition, over two hours of work in the past can now be completed within two minutes.

Personal privacy concerns

Another concern which may lower the response rate is personal privacy.

Today, private and public organisations have scattered personal information. The U.S. Census Bureau has conducted an internal experiment, combining data from commercially available databases with anonymous data from the 2010 U.S. Census, it was found that 52 million people's names, gender, age, race, and more, could be correctly connected. In view of this, the bureau uses mathematical formulas of "differential privacy" to adjust the census data. By adding slight modifications in the use of the data, they can effectively balance privacy loss and accuracy, without jeopardising academic research and business analysis.

Furthermore, the social changes in recent years and the Covid-19 epidemic have raised concerns about the public's response to the census in both Hong Kong and the U.S. To encourage a better response among the "hard-to-survey populations" who had a less than 50% response rate in the past, the U.S. authority studied their demographic characteristics in order to tailor solutions. GIS was used to analyse that along with lifestyle segmentation data such as income, age, interests, and more, a technique often used by marketing executives.

Optimise response rate

Six segments were then identified as follows:

1. Dorms to Diplomas (22% response rate):
- Median age of 21
- Living in neighbourhoods with a mix of dorms and on-campus/off-campus housing

2. City Lights (31% response rate):
- Median age of 38
- Above-average incomes
- Lagging behind the general population in net wealth

3. Young and Restless (41% response rate):
- Median age of just under 30
- Highly mobile
- In their early careers when changing address is frequent

4. Modest Income Homes (44% response rate):
- Just 50% of labour force participation rate
- Income below half of the U.S. median
- Relying heavily on public transportation

5. Metro Fusion (45% response rate):
- More than half being single-parent and single-person households
- Median age of 28
- Median household income of US$33,000 (below half of the U.S. median household income of US$68,000)

6. City Commons (46% response rate):
- Nearly one-quarter of people receiving public assistance or social security benefits
- Typically living in large cities and renting apartments in mid-rise buildings

Source of info: Esri

According to their characteristics and home address, the authority encouraged them to respond to the census questionnaires through different media outlets, emails, leaflets, TV commercials, and radio promotions. As a result, the two segments Modest Income Homes and City Commons had a surprising response rate of 54%, although they were the least likely to select the web for submitting their responses. For the Dorms to Diplomas segment, which had the lowest response rate of 22% historically, the response rate is now 77%. With the use of advanced technology such as GIS, the census was successfully accomplished.

2.13 Elderly service planning in Greater Bay Area

The problem of ageing is unprecedented, the world is groping for ways to address it. While there are almost 36 million elders aged 65 or over in Japan, the situation in China follows the same path. Take our neighbouring Guangdong Province (GD) as an example, the population aged 65 and above is expected to exceed 10 million in 2020 and well above 30 million in 30 years' time.

One of the key challenges of ageing is a heavy healthcare cost. According to a Japanese research institute, the average annual healthcare cost of the "extremely elderly", that is 85 years of age or above, is estimated at 1 million yen (about HK$74,000), of which hospitalisation costs account for more than half. In Hong Kong, based on a forecast by the Census and Statistics Department, the over-85s group will rise sharply in 10 years, i.e. 2031, and the rapid growth is expected to remain for 20 years. The "extremely elderly" will reach over 800,000 which is four times today, and will stay from 2049 onwards for years. Individuals and society as a whole would be under immense financial pressure.

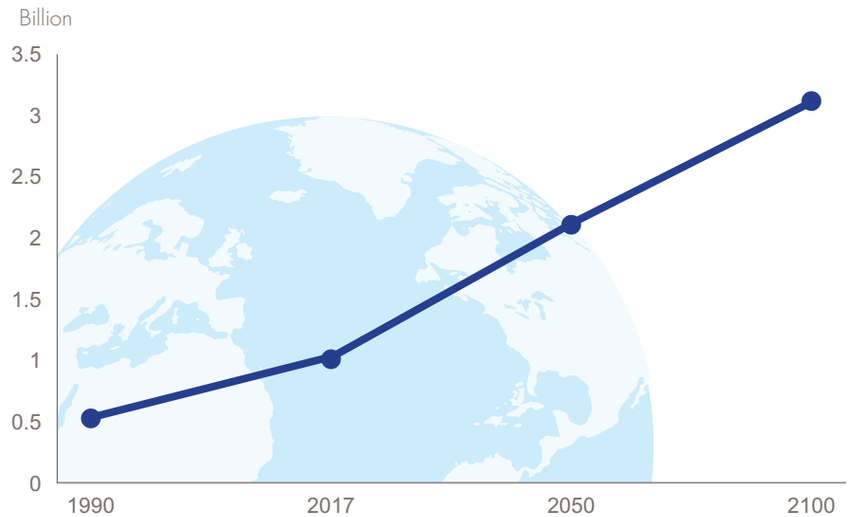
Varieties to suit different needs

Healthcare is only one dimension of the issue. A survey of elderly services in the United Kingdom interviewed 3,000 people aged between 45 and 75, the majority of whom own their houses and therefore can afford to be choosy

"The 3D map of GIS shares the planning process and other information of elderly services on a visualisation platform with other departments and the public; promoting efficiency and communication."

Ageing is a global challenge.

Projected growth of global population aged 60 or above



Source of info: United Nations

when it comes to care in late life. Their number one concern is internet access (97%) for keeping in touch with friends and family (83%) and the world (76%), as well as for entertainment (51%). 86% of them "want a hot meal to be served at dinner" (currently, serving hot meal at lunch is more common there); 80% think "freedom of life" is the most important factor for the choice of care provision; and 55% want to move into an elderly home with their partner.

The above wish list could be shared with many Hong Kong people. In fact, with a total population of more than 10 million elders in Guangdong and Hong Kong, we could offer more choices according to socio-economic factors, family background and health conditions.

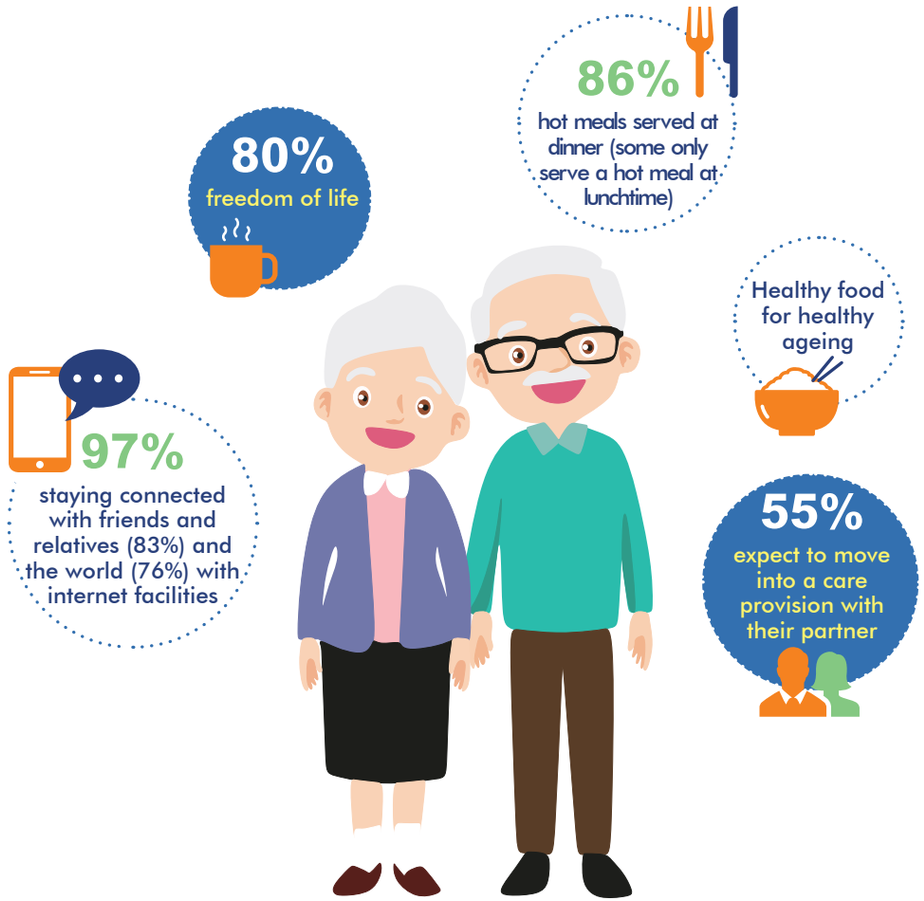
At present, the elderly service in Hong Kong is far from ideal. The general public has a poor impression of privately run elderly homes, and the government's subsidised residential care service for the elderly is also inadequate with a waiting time as long as 41 months.

Quality ageing requires better urban planning

Due to the differences between GD and Hong Kong in social and cultural aspects, currently, most local elders are not comfortable to move to GD for retirement, and the problem needs to be sorted out by the two governments. In the long run, however, under the overarching trend of integrating Hong Kong into the Greater Bay Area (GBA), we should start to collaborate with their government to provide high-quality services for the elderly.

This will involve land use and housing, transport, infrastructure, labour force and more. In face of such a large and complex planning issue, a geographic information system (GIS) can come into play. GIS, an electronic mapping

A British survey reveals elderly people's expectations for late life.



Source of info: Caterplus, UK

software, efficiently aggregates, organises, analyses and visualises all location-related data.

Through GIS, authorities can readily identify suitable land, such as gentle slopes of less than 25 degrees, reducing the cost of land preparation; land not far from main roads and cities, avoiding the most dangerous road sections, which is convenient for staff to commute and for family members to visit; and government land to avoid excessive land cost. This is the first step. Then the authority can incorporate other requirements into its planning, such as to create more elderly home choices for people of all incomes.

GIS helps to balance growth with social equity

Take Seattle, the fastest growing city in the United States as an example. With a number of technology companies in the area, employment increased by 30% over the past decade with the population rising by 23%. The city government has to juggle the need to absorb 60 new residents a day while maintaining housing affordability and balancing the impacts of a widening prosperity gap.

However, the Seattle authorities uphold the principle that while building more houses, it must also take care of the disadvantaged and maintain considerable farmland and open space.

The government has pursued several strategies to encourage more accessory dwelling units in single-family neighbourhoods, including removing regulatory barriers, and streamlining the permit issuing process. These take many forms, such as conversions of garages, basements, and backyard cottages. These units can provide new, space-efficient rental homes in neighbourhoods where housing is often unaffordable for most people. And to their owners, the new

settings can generate additional income. A zoning change is also passed that allows taller building heights and requires developers to create more affordable housing.

3D visualisation tools for collaboration

Meanwhile, the local legislation requires an updated inventory of available land every seven years. The buildable lands inventory measures development and reviews resultant population densities against the prior plan's growth forecast. However, the complex zoning plans and site guidelines are at least 10 inches thick if printed, but would be simple and convenient with GIS software.

At the same time, one of the key capabilities with GIS, is that 3D city modelling can facilitate efficiency and smooth communication for interdisciplinary planners and design professionals which enables collaborative scenario planning and impact assessment. What's more, with all planning workflow being on one platform, from data collection, analysis, visualisation to sharing of information with other departments and the public, and even decision-making will be made easier. Instead of using hard data, the 3D tool visualises the what-if scenarios, showing estimated housing units under the supply of existing land with maps, charts and graphs, facilitating the participation of different stakeholders such as nearby residents, and in turn promoting social harmony.

Hong Kong, which introduced GIS more than 20 years ago, is a pioneer in Asia. Therefore, in terms of land use, we can take the initiative to communicate more with the Mainland to optimise urban planning and enhance the competitiveness of the whole GBA.

2.14 Geographic information supports Mars landing missions

Where will you be in 10 years time? Hong Kong? London? The Greater Bay Area? Or Mars? Although Mars seems so far away from us, SpaceX founder Elon Musk said that his starships would be landing on Mars well before 2030. In July 2020, China, and the United Arab Emirates started their journey to Mars with the United States continuing their previous exploration. Recently, China's Tianwen-1 announced a successful landing. Behind the landmark project is a group of Hong Kong scientists.

One of the purposes of exploring Mars is to understand the origin and evolution of life, while Mars may also be the future home of mankind. However, the current success rate of Mars exploration missions is only around 50%, the main challenge is the entry / descent / landing (EDL) process, according to the China Academy of Space Technology. To ensure a smooth landing, the scientists need to conduct detailed surveys on the berthing orbits and the landing area to obtain sufficient data on the topography and assess the probability of sandstorms there.

The geographic information system (GIS) which is good at collecting, organising and analysing data, plays an important role in these surveys.

Hong Kong's contribution

The environment of the red planet is quite different from that of Earth.

“GIS not only maps a safe landing site for space exploration and quickly analyses the spatial data, but its visualisation function also arouses the public's interest in advanced technology.”

The atmosphere of Mars is thin and very unstable under the influence of its seasons, day and night cycle, and Martian dust storms. The latter are also more violent than that of Earth. In addition, the Mars surface is full of obstacles such as rocks, slopes, and ravines, the terrain is complex. According to Professor Bo Wu from the Hong Kong Polytechnic University’s Department of Land Surveying and Geo-Informatics, the potential landing site covers an area of about 70km × 180km which is about 11 times larger than the size of Hong Kong, however, there is no relevant survey data for the Mainland’s project team and this makes it difficult to assess the risks of landing on Mars.

To analyse the topography and landforms of Mars, Wu’s team first collected historical data from Europe and the United Kingdom, and then constructed 3D digital topographic models of the target landing region using the self-developed integrated 3D mapping model. With the aid of artificial intelligence’s deep learning, within 1.5 months, the team successfully studied more than 670,000 craters, over 2 million rocks, and hundreds of volcanic cones distributed over the potential landing site, additionally steep slopes too hazardous for landing were also identified. As a result, the best site which is in the southern part of the Utopia Planitia in the northern hemisphere of Mars was identified for the landing.

The PolyU team is experienced in the Mainland’s aerospace missions. It had participated in the Chang'e-3 to Chang'e-5 lunar exploration projects, such as the research project called Chang'e-4 Landing Site – Topographic and Geomorphological Characterisation and Analysis, and collected a large amount of lunar remote sensing data. The team used GIS to create a high-precision and high-resolution terrain model for the potential landing sites of Chang'e-4, and analysed the geographical features of the area. The analysis helped the team make reliable recommendations for the possible landing sites, laying a solid foundation for the world’s first landing on the back of the moon. GIS also helped the team analyse various spatial data collected from the moon effectively, including that from about 400,000 craters and more than 20,000 boulders. At the same time, GIS was also used to calculate the gradient of the slopes to locate a relatively flat surface for the safe landing of Chang’e-4.

How GIS helps

China is a rising star in aerospace missions and has made rapid progress in recent years. The U.S., on the other hand, has over 20 years of experience in exploring Mars with the National Aeronautics and Space Administration (NASA) having started the Mars exploration project 20 years ago. A satellite, 2001 Mars Odyssey, was sent to collect a large amount of data, including Mars landform and surface mineral data for study to determine if there were signs of life. In February 2021, NASA’s Perseverance rover arrived on Mars for planetary exploration.

However, Mars' surface is full of scattered jagged rocks and boulders which add many difficulties to Perseverance's mission, therefore careful planning is essential. For this purpose, NASA and its Mars Science Laboratory (MSL) used GIS software to combine images from three remote sensing satellites that have orbited the red planet for many years, to improve their understanding of Mars' diverse terrain and complicated geography. The first task was to survey a potential landing ellipse, which could be very broad, like the one for Phoenix Mars rover in 2008 measuring about 100km x 19km. Through GIS, the team constructed a map covering 85% of the landing ellipse which is sufficient to support a smooth EDL.

At the same time, judging from the channels and canyons on Mars, it had a lot of liquid water flow marks a long time ago. MSL needed to study in more details the chronology, geophysical processes, and whether life existed on Mars. Therefore, in addition to landing in a geologically rich area and with relatively flat terrain, MSL also had to make sure the rover could navigate with minimal obstacles. Furthermore, scientists made use of computer programmes such as a GIS software, ArcGIS, to study the mineral compositions of rocks, the presence of water, and temperature differences to find potential organisms on Mars.

See Mars for yourself

In May 2021, thousands of Hong Kong people gathered around the waterfront to watch the full lunar eclipse. It shows the public's interest in astronomy. Now, people who want to explore the red planet can also interact with a 3D map of Mars online at https://explore-mars.esri.com/. You can measure different terrain such as the size and altitude of a crater on Mars, or to place a country such as China on the 3D map of Mars to see it at an appropriate scale. You may be surprised by the small size of Mars when compared with the Earth.

All of the above is made possible through the visualisation function of GIS which enables the general public to appreciate advanced technology. Young people in Hong Kong can even experience this advanced technology personally. Since 2016, all primary and secondary schools in Hong Kong can use the professional software GIS for free by joining an e-learning programme called Map in Learning (MiL). Today, more than 220 schools have participated in the programme with over 1,700 teachers and students having been trained.

I hope that more schools will join MiL in the future to enhance young people's intelligence in multiple disciplines, so that their creativity and potential can be fully developed. Perhaps one day it will bring ground-breaking innovations for our outer space exploration.

Summary

Through GIS, the scattered data of a city's geomorphology, demographics, infrastructure, and resource distribution are integrated, so that decision makers can use a holistic view to better plan infrastructure, railway systems, road networks, clean energy, population census, elderly services, aerospace development, and to fight the epidemic.

Startups use data to realise their inspiration

03

Many young entrepreneurs all over the world have carved out a niche by making good use of spatial data to improve people's lives, examples include: Mapillary and StreetScan which enhance road conditions and facilitate drivers, Fishery that increases the fun of fishing activities, Match Rider that provides a ride sharing service, and more. Hong Kong young people can learn from them and prepare themselves for the upcoming challenges.

3.1 Geographic information is both valuable and marketable

One of the major events of the map industry in 2020 was Facebook's acquisition of a startup called Mapillary.

What is Mapillary? Many drivers have such an experience: The road that was clear not long ago is now obstructed, and the driver is forced to change to another route, causing unforeseen delays. The eight-year-old Swedish startup has been working with the public to collect and bring together hundreds of millions of street images from around the world to update city maps continuously.

Crowdsourcing street images

Mapillary, a mapping platform, encourages citizens to use smart phones or any kind of camera to take and upload street images. The company then recognises the icon or text of street signs, traffic lights, and traffic lanes in the images through a computer vision, then these are stitched together into a three-dimensional map.

By the end of 2021, Mapillary had collected more than 1.5 billion street-level images, covering 190 countries through crowdsourcing.

Apart from helping drivers to grasp the latest road conditions, it can also assist in disaster relief. For example, street images after the Philippine

"GIS can be used to analyse geographic data and develop solutions which optimise the value of data. The startup Mapillary acquired by Facebook is an example."

Mapillary encourages citizens to upload street images to help drivers grasp the latest road conditions through 3D maps.

typhoon have facilitated the delivery of resources; while drivers in Ghana, West Africa can be more aware of the poor road conditions with the latest street images which help to lower the surging traffic accident mortality rate over recent years. At the same time, the application has also contributed to the clearing of leaves which fell onto the streets of Washington D.C. in the United States. These map data are shared with the public, and you can also make your own map of interest here.

80% data related to location

There is a famous saying in the mapping industry: 80% of data is related to the location. Geospatial data is getting more and more important, resulting in many technology giants striving in this field.

According to the latest research from scholars in the U.S. and Singapore, Facebook, Apple, Amazon, Microsoft, Uber, and Southeast Asia ride-hailing service leader Grab, are all actively participating in the world's largest free geographic information platform OpenStreetMap, although they have different focuses in doing so. For example, Grab hopes to improve the street data of Southeast Asia such as Indonesia and Vietnam, while Facebook launched a project called AI-Assisted Road Tracing early in 2016 to test various machine learning algorithms and to improve the mapping workflow, for example by detecting roads from satellite images. Through the acquisition of Mapillary, Facebook could become much more powerful in the mapping arena.

Mapillary's free use was originally limited to non-profit-making purposes, and commercial uses were charged. But after Facebook's acquisition, commercial use will also be free of charge. Some commentators said that this was to strike at opponents, and to strengthen Facebook's ecosystem, where most users upload photos to Facebook. These users could use the Mapillary map to mark the photo location, and Facebook could then completely monopolise the precious information provided through customer interactions.

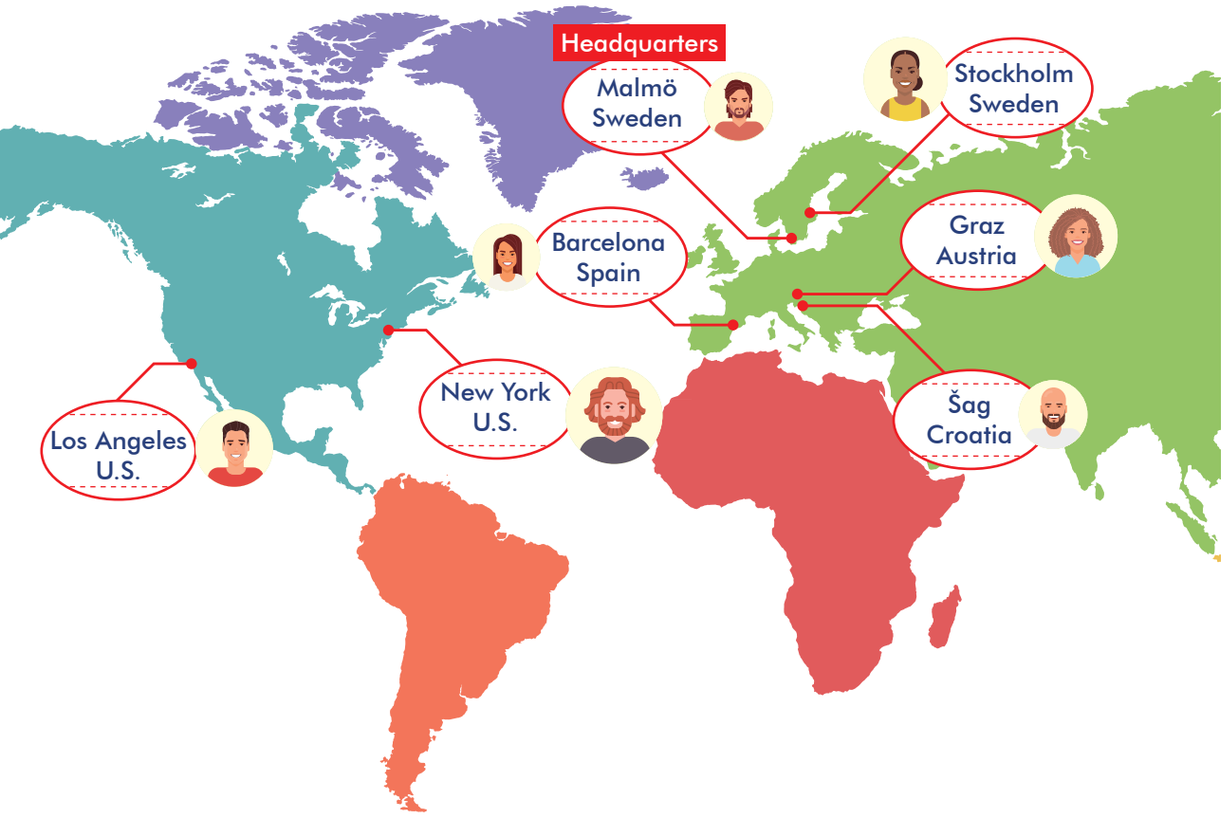
Smart talent management

Talking about its successful formula, Mapillary's founder and CEO Jan Erik Solem pointed out that European technology companies did not possess a big market and talent pool comparable to the U.S and China, so they had to think globally from day one. This is in terms of market coverage, working team, and operating model.

As the world is competing for talent, such as engineers in artificial intelligence, software development, and machine learning, of which the demand in the United Kingdom increased nearly fivefold between 2014 and 2017, Solem has demonstrated his "think globally" philosophy.

First of all, the team he manages is internationally diverse. The company is headquartered in Malmö, Sweden's third largest city with more than 50 employees spanning across several time zones, including Barcelona in southern Europe, Graz in Austria, Los Angeles and New York in the U.S., Stockholm in Sweden, and Šag in Croatia, etc. He allows employees to "work where they want and when they want". This attracts excellent talent, and also enables the company's employee turnover rate to remain at a low level with a staff retention rate of 97% within the first four years of founding, which is quite unusual for many startups.

Mapillary's flexible talent management with 50+ employees spaning across several time zones



Esri Startup Programme

Mapillary is currently one of Esri's global partners. The company joined the Esri Startup Programme (the Programme) early in 2015 to get comprehensive support from Esri.

Esri is the global leader in the geographic information system (GIS) and one of the world's top 50 software companies. The Programme is designed for young software companies within less than three years of founding and with an annual turnover of less than US$1 million. Selected startups can use the company's GIS software ArcGIS for free, they can also participate in the world's largest Esri User Conference to exchange ideas with more than 20,000 professional users. The conference is actually a golden opportunity for startup entrepreneurs to see the world's most exciting demonstrations of GIS, broadening their international possibilities and networks.

In fact, various companies with different purposes have participated in this Programme, from navigation, and logistics, to unmanned driving using geospatial data. I believe that these data still have much potential to be realised, and our imagination is the key. I look forward to different talent joining the exploration and seeking greater well-being for the community.

(Remark: Facebook Inc. announced the company would be renamed as Meta Platform Inc. in October 2021)

3.2 Startup ideas (1): Carpooling, fun for leisure activities

Having established in the United States for over 50 years, Esri is one of the 50 largest software companies in the world. Its renowned Esri Startup Programme (Esri Programme) supports startups whose core business uses geospatial information. In fact, the companies which have participated in the Esri Programme address a broad spectrum of industries such as ride-sharing, public safety, city management, utilities, natural resources, health, commercial sectors, and more.

For example, Match Rider, who joined the Esri Programme years ago, has a mobile application that helps passengers with carpooling.

Ride-sharing solution for greener future

Match Rider was founded in 2012 in Heidelberg, Germany. It was originally a ride-sharing service platform, connecting drivers and passengers, serving destinations within 100 kilometres. The company is also supported by the largest public bus and light rail company SSB in Stuttgart to pick up passengers and then connect them to the central interchange station. The participating drivers are not making profit, they are ordinary drivers. They pick up passengers on their way to work and only charge as much as €180 (about HK$1,600) per month to subsidise fuel and maintenance costs. The passengers pay €0.15 (about HK$1.3) per km. Today, it reliably offers trips at peak times every 10 minutes at their pick-up points, just like public transportation services.

"The Esri Startup Programme supports startups from ride sharing services, business management, marketing, business travel planning, road maintenance, and wildfire monitoring, etc."

German startup Match Rider connects drivers and passengers who need to go to places like the central interchange station.

This company's algorithms calculate the most convenient pick-up and drop-off locations for both drivers and passengers, such as nearby stations or bike-sharing stations, so that drivers do not need to take any significant detours to pick up passengers. It provides a convenient and affordable service to travellers, which saves energy and helps improve traffic congestion at the same time.

The performance of Match Rider in recent years has been widely recognised. At the "Transforming Mobility 2020 Award", hosted by the Ministry of Transport in the third largest state Baden-Württemberg in southwest Germany, the company defeated 15 teams and became one of the three winners.

I appreciate this service model that brings a win-win-win situation to drivers, passengers and the environment. Actually in Hong Kong, some drivers take a similar initiative to pick up fellow travellers for free from time to time, in the New Territories in particular, but the service is mostly irregular, and without coordination. Perhaps this German startup can inspire Hong Kong.

Professional service creates more fun

Meanwhile, I wonder if leisure activities with professional assistance will double the fun and increase the sense of accomplishment. This is the key to the success of another startup, Fishidy, which is also a participant in the Esri Programme.

Fishidy is a mobile application for anglers in the U.S. It integrates interactive fishing maps, real time and forecast updates of the weather, peer communication, and information on thousands of waterways (the location of large rocks, depth contours, bathymetry, and types of water bed), lakes, and tides. Most importantly, the application helps users find nearby fishing hot spots and offers travel directions. It gives anglers the best possible tips and information which then allows them to have successful fishing trips.

This fun and practical application was launched in 2012. It has received an overwhelming response from experienced players and newcomers. Within one year of launch, the number of members approached 150,000, and has since climbed to over 1 million. In 2018, the startup was acquired by FLIR, a world-renowned designer and manufacturer of thermal imaging cameras and sensors.

Hong Kong: more sophisticated hiking guide

In Hong Kong, fishing is not as popular as hiking. However, the current hiking information is scattered, and many are not up to standard. For example, a website previously introduced a popular hiking route in the urban area, from Quarry Bay to Tai Tam Reservoir via Mount Parker. The journey only takes a few hours, a good choice for family outings. However, the website suggested taking hiking equipment like a night light and an emergency thermal blanket, which is quite ridiculous. In fact, this hiking trail extends in many directions. If there is a mobile application linking GPS and spatial information to give directions to different hotspots, such as the abandoned cable car, the children's favourite tadpole pool, and the less known stream close to Tai Tam Reservoir, it will definitely add more fun to hiking, and also improve the safety of outings.

The above two startups show that making good use of geographic information can create much value in our lives, from enhancing travel convenience to making leisure activities more fun.

3.3 Startup ideas (2): Enhanced accessibility and walkability

Smart Mobility generally refers to real-time traffic information or the avoidance of traffic congestion. No wonder Google acquired Waze, an Israeli startup that crowdsources traffic data, for US$1.3 billion in 2013. However, improving road safety is actually equally important for our daily lives.

Road health management and work prioritisation

A poor road surface can hinder a smooth journey. StreetScan, a United Status member of the Esri Startup Programme (Esri Programme), uses vehicles equipped with 3D cameras and sensors to check the conditions of roads and pavements, traffic lights, street signs, and the brightness of street lights without interrupting the traffic; it then analyses the data with trained algorithms. The only exceptions are sections neighbouring schools and busy roads which will be given priority. The analysis allows the authorities to enact better planning and budgeting.

StreetScan had a successful experience in Newton, close to Boston, U.S. In the nearly 400-year-old city, Newton residents are disturbed by ageing streets and facilities. Due to a lack of data, it is difficult for the authorities to decide which section should have higher priority.

The startup collected information on the city and found that its overall

"GIS, 3D lenses, sensors, and mathematical calculations are used to improve road safety, so that drivers and mobility impaired people can travel with peace of mind."

pavement condition index (PCI) was 62.5, about 12 points below the standard. With this objective and data-driven approach to analysis, the city was able to secure US$100 million for a 10-year pavement improvement project aiming to raise the sidewalk condition.

StreetScan was founded in 2015, having originated from a research project of a civil engineering student at Northeastern University. The company provides the management and evaluation of road facilities for different local governments based on a geographic information system (GIS). Only a year into its operations, the company's pavement monitoring platform had already been used by 15 cities in the U.S. and generated interest from other countries like Canada, China, and France.

Improved walkability for the disabled

At the same time, as the population ages, more people need aids such as walking canes and wheelchairs. 3.6 million people in the U.S. alone are wheelchair users. Obstacles as little as slopes can pose a difficulty to their mobility and independence. If we also count those visually impaired, the people in need of updated and even real-time sidewalks information will be

PathVu uses its own self-proprietary stroller-type sidewalk profiling tool which is equipped with GIS, multiple sensors and video cameras to collect details of the road surface, and display the information on a map.

even more numerous.

PathVu, another member of the Esri Programme, started building a pedestrian facilities database in 2014 and uses real-time maps to guide people with special needs. This service idea originated from a study by the University of Pittsburgh which found a correlation between the surface texture of pedestrian facilities and the health of wheelchair-bound users who travel on them. The brother of the company's founder, also a wheelchair user and technical director of the company, offers a highly valuable perspective for the service.

Using their own self-proprietary stroller-type sidewalk profiling tool which is equipped with GIS, multiple sensors and video cameras, they can collect details of the road surface, such as roughness, longitudinal slopes and cross falls, tripping hazards, the distance to corners, and more. The information is displayed in real-time on a map. Smartphone users can also upload road obstructions through the company's app and rate its severity. So far, the platform has mapped 640,000 hazards and obstacles. The company wants to use the power of crowdsourcing to expand the service around the world so that global accessibility can be improved.

In Hong Kong, the government estimated that the total number of people with a "restriction in body movement" or a “seeing difficulty” was over 578,000 in 2013, an increase of more than 60% over 310,000 in 2007. I believe the number is much higher today. At the same time, the Highways Department received more than 5,000 complaints of footpath damage each year from 2016 to 2018, updating the record of obstacles to the mobility of the disabled. Therefore, I hope that startups in Hong Kong can help solve these critical issues, which would improve our living conditions and could also make startups a success.

3.4 Startup ideas (3): Wildfire forecasts, customer communications

It is estimated that the global population was less than 1 billion at the beginning of the 19th century. Today, 200 years later, the world's population has soared to 7.2 billion, and is expected to reach 10 billion by 2050. As a result, humans have to compete with all other creatures for natural resources. Human activities have caused global warming which has caused the world many problems. One of them is the drastic decrease in worker productivity due to hot weather, the other is serious wildfires. In 2019, Australia's bushfires caused 17.1 million hectares of scorched earth (about 155 times the size of Hong Kong), and 1 billion animals suffered from the disaster. In 2020, wildfires on the west coast of the United States killed dozens of people, the smoke even spread to Europe, which is 8,000 km away.

Empower communities to limit wildfire impact

As long as the issue of global warming has not been adequately addressed, the frequency and scale of wildfires will only increase in the coming years. This troubling issue has driven startups to find solutions, such as FlameMapper, a member of the Esri Startup Programme (Esri Programme).

The two founders, one elderly man and one youngster, have both suffered from wildfires in the past. A 10-day fire in Malibu, Los Angeles, California destroyed more than 300 houses, including the 8-year-old Shea Broussard's home. Although the elder Anthony Shafer's home remained intact fortunately, the effect is in his mind.

"Using AI to prevent wildfires and machine learning to detect dissatisfaction expressed on social media are examples of using GIS to solve customer problems."

The startup was founded in 2015, and uses artificial intelligence to prevent and manage wildfires. It helps planning how to protect infrastructure, provide evacuation routes, and pinpoint high-risk locations in case of wildfires. When the wind direction changes on the spot, the prediction model can be adjusted in near real time to help firefighters, the government, and public organisations, including power companies and schools to determine the priority of assigning resources. According to the startup company, these forecasts can help to protect important public facilities and reduce the extent of damage by 70%.

In the event of a major incident like a wildfire, apart from disaster relief, it is also important to ensure close communication between relevant units and the public; this can guide all parties to cooperate and avoid panic. DataCapable, founded in 2013, also a member of the Esri Programme, is enabling these rescue efforts.

FlameMapper's forecasts help protect important public facilities and reduce the extent of damage by 70%.

Close communication gap between communities and businesses

It collects and analyses data extensively, and uses machine learning to detect special incidents, such as gas leaks, wildfires, earthquakes, power outages, school shooters, and more. It can often send out an alarm to customers and emergency centre operators 40 minutes earlier than traditional event awareness workflows and systems.

For example, Seattle City Light, one of the top 10 public power companies in the U.S., serves over 400,000 residential and commercial customers. When a power failure occurs, it will certainly cause much customer dissatisfaction. DataCapable sorts out the comments on social media, and immediately reports the dissatisfied messages to the power company for them to handle as quickly as possible. At the same time, when and where these messages were initiated, as well as relevant information such as the demographic characteristics of the district, customer behaviour data, and the natural environment are all displayed on a map dashboard, so as to assist the company in making decisions.

In addition, DataCapable provides utility companies with real-time power outage reports, customer sentiment feedback (how many people are expected to be dissatisfied), and weather data (indicating power outage possibility) to help improve service satisfaction. In fact, FlameMapper and DataCapable are business partners, and they complement each other to solve problems for their customers.

3.5 Startup ideas (4): More effective business support

> *"The startups supported by the Esri Startup Programme come from all corners of the world, including the U.S., Russia, Italy, Sweden, and Germany."*

The Esri Startup Programme (Esri Programme) supports startups which use geographic information in their core business. The companies participating in the Esri Programme have diversified business interests, they include American companies as well as startups from many other countries around the world. SmartLoc from Russia is an example.

Geomarketing helps identify potential customers

How many potential customers does your store have? Which district has insufficient retail facilities? How many shoppers can your mall attract?

SmartLoc, headquartered in Moscow, uses spatial data for market research, analyses location selection for real estate companies and retailers, and develops related IT solutions. The company's major market is the Commonwealth of Independent States ("CIS") formed by nine countries including Russia and the former Soviet Republics, such as Armenia, Kazakhstan, and Uzbekistan.

For retailers who want to open new stores, the company provides information on the population density and characteristics of each city, as well as the pedestrian traffic, the latest social and economic data, the composition and size of anchor tenants, and spatial data in the prospective environment. This information is alongside new building details, real estate transactions and leasing information, all of which affect the success or failure of establishing a business. For real estate developers, the company also analyses market factors of the areas to be developed, such as the footfall and traffic flow, the demographic characteristics of residents in the same district, and the existence of competitors. It also uses Huff's model to measure the prosperity of the location, and uses machine learning algorithms to forecast investment returns.

As Azat Imangalin, Chief Executive Officer of SmartLoc said, "In the past, large companies might spend tens of millions of Rubles on site selection, our company offers convenient and flexible solutions that do not require such investments."

The company has been established for less than 10 years, but the list of customers is quite impressive, including the largest local retail chains, real estate developers, and internationally renowned brands such as IKEA, KFC, PWC, Domino's, Pizza Hut, and more.

From trip planner to scheduling

For companies with a big team of field workers, it is a headache to allocate every team member's itinerary which is required to be efficient, cost-effective, and on schedule. Italian startup MobyPlanner thought of helping them manage their busy itineraries based on geographic location. Through an easy-to-use mobile application, it combines a large amount of data to provide the best travel route and avoid congested roads. In case there are any changes to the itinerary, the application will automatically update and check if it clashes with other activities. At the same time, the application keeps field staff in contact with the company, the company can also display both the whereabouts of each worker, and the summary of each one's daily schedule on a dashboard.

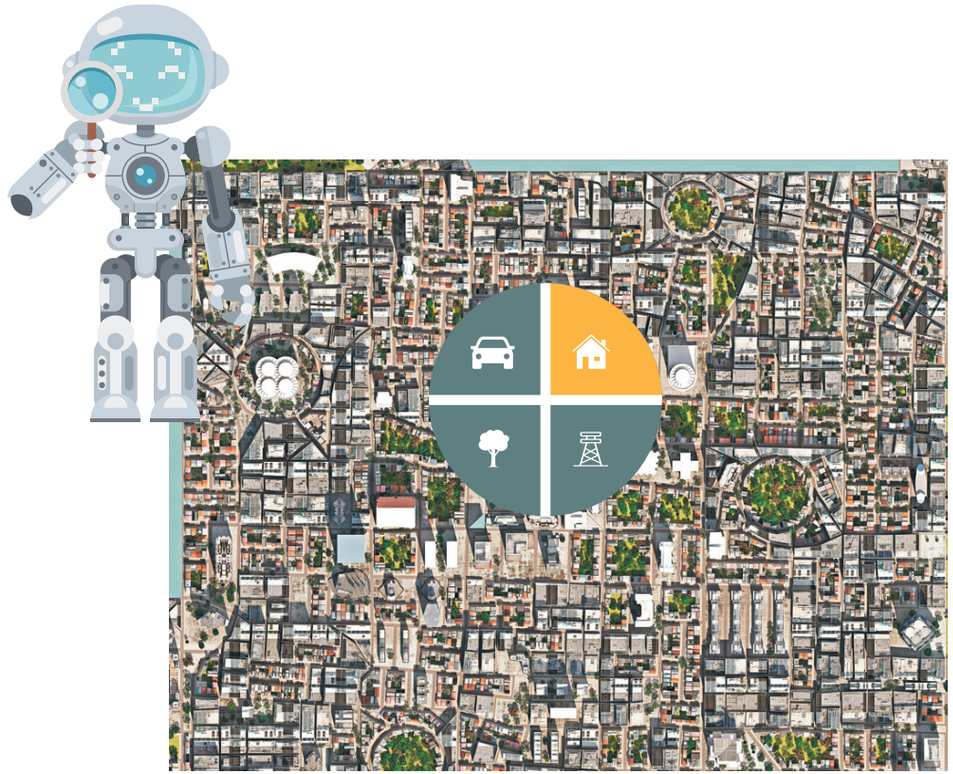
Take claims management in the insurance industry as an example. It involves a complex process with many procedures, and requires relevant personnel to conduct on-site investigations. With the help of MobyPlanner, up to 200 activities can be arranged in five minutes, compared with a few hours in the past. Additionally, due to the smooth travel route planning, it is reported to have saved an average of 15% of travel time.

In addition to the insurance industry, others such as power, energy, entertainment, public works, and retail, as well as many marketing firms, could use this tool to streamline daily operations.

Digitise the world with aerial insights

TerraLoupe, founded in Munich, Germany in 2015, of which the name means "magnifying glass of terrain". As the name implies, through artificial intelligence such as deep learning algorithms, aerial images covering

TerraLoupe recognises houses, roads, parking lots, and railways through artificial intelligence, benefiting industries such as autonomous driving, real estate, agriculture, and gaming.



houses, roads, parking lots, swimming pools, green areas, railways, and infrastructure are systematically recognised. With various real-world objects in cm-accuracy, the digital images are accurate even to the size of a window and then displayed in a 3D map. The technology benefits industries such as automotive (e.g. autonomous driving), insurance (property valuation), real estate, agriculture, security, tourism, and even gaming. The company's customers include German railway company Deutsche Bahn (DB), global provider of reinsurance Munich Re and BMW.

As early as 2017, when the three founders of TerraLoupe were interviewed by the media, they expressed their wish to tap into the United States and China markets after establishing a firm foothold in Europe. In 2020, the company was taken over by Edge Case Research, an American autonomous driving technology company. Thanks to TerraLoupe's advanced technology, I believe that the development of self-driving technology will definitely take a big step forward.

The above three startups share the same characteristics: they make good use of huge geographic data to solve problems in employee trip arrangement, asset management, or business development for corporate customers. These solutions are more affordable, convenient and user-friendly than traditional ones. Although these startups have been established for less than 10 years, they already have outstanding achievements and have gradually transformed from Esri's supported startups to Esri's partners in recent years, enjoying the company's geospatial cloud technology and the facilitation of their business development.

3.6 Developing the IT potential of girls

At the year end of 2020, a recruitment platform announced the results of a survey on the projected salary increment of various industries in Hong Kong over the following year, which is an annual 'hot' topic in the city.

The survey interviewed more than 400 local companies, and found that employers expect an average salary increase of only 0.8% in 2021, the lowest since 2010. A relatively big salary increment was expected for positions related to digital transformation, like 3.8% for data analysis work. According to the recruitment agency, this reflected how many companies see a continuing demand for data analysts, programme developers, interface designers, and more, so that they can better understand their customers' consumption patterns through these experts.

Income inequality between genders

This trend is not surprising in the era of big data. I am more concerned about whether girls can benefit from the trend. Under the epidemic in 2020, the employment data showed that women, especially the younger sector aged 15 to 24, were adversely affected. Will there be a turnaround in 2021?

In July 2020, the government announced survey results on Men and Women, indicating a huge pay gap between the two genders. Based on 2019 data, the overall salary of women was 24% less than that of men. In "public

"The Map in Learning programme allows primary and secondary schools in Hong Kong to use professional GIS software free of charge to help students develop their diversified potential."

administration, social and personal services" industries where over 70% of employees are women, their average salary was less than men by one-quarter for the same position, while men's monthly salary was even 35% higher than women's in the "information and communications" field.

Salary is supposed to be linked with academic qualifications. Nowadays, many girls have outstanding performance in schools. In 2019/20, girls accounted for about 53% of bachelor's degree students. In "top programmes" that require high admission scores, such as medicine and dentistry, the number of female students has steadily increased from more than 40% to 60% over the last two decades.

However, the majority of female students still concentrated on subjects like education, arts and humanities where over 70% of students have been girls during the same period of time.

Encourage girls to study IT related subjects

On the contrary, for subjects that are related to "data analysis" which is

Over the past two decades, the preferences between female and male university students have remained almost the same.

	2001/02	2019/20
Medicine		
Female	47.8%	50.5%
Male	52.2%	49.5%
Engineering and technology		
Female	25.0%	29.2%
Male	75.0%	70.8%
Arts & humanities		
Female	76.1%	71.0%
Male	23.9%	29.0%
Education		
Female	75.2%	73.5%
Male	24.8%	26.5%
Total		
Female	**54.4%**	**52.8%**
Male	**45.6%**	**47.2%**

Source of info: University Grants Committee

becoming popular nowadays, there are very few female students, similar to the situation 20 years ago. These subjects are science (female: 38%), and engineering and technology (29%). Therefore, we can infer that girls may not necessarily benefit from industries with the best salary prospects in the coming years.

The Map in Learning programme facilitates female students to develop multiple intelligences.

Encouraging females to study IT related subjects and to engage in IT-related work, not only promotes competitiveness, but also enhances their social and economic influence.

That's why I launched Asia's first e-learning project, Map in Learning programme, in Hong Kong in 2016, allowing primary and secondary schools in Hong Kong to freely use the professional geographic information system (GIS) software which had been exclusive to the government, and public and private enterprises in the past. This electronic map software helps students to develop their potential.

This GIS software collects, integrates and analyses data in a graphical manner, which is easy to read and understand. It not only improves the problem-solving ability of young people, girls in particular, but also helps them communicate and cooperate with others.

I hope that more girls will be employed in the new economy industries in future, and that they will work with us together for a future smart city in Hong Kong.

3.7 Latest education trend: Integrating GIS with STEM

STEM (science, technology, engineering, mathematics) education has been advocated for about 10 years, and has become one of the most sought after subjects in Hong Kong. Let us now look into some new developments in relation to the topic.

In the past, some people might have viewed geographic information systems (GIS) as solely a geography subject. Recently, however, Germany, Switzerland, the United Kingdom, Australia, the United States, and Canada have all integrated GIS into STEM education, according to Dr Michael Gould, Global Education Manager of Esri and a professor of GIS at Universitat Jaume I in Spain.

GIS helps students use spatial data to link various information through electronic maps. The possible factors behind a problem can be presented clearly in layers, making it easier to figure out not only the most probable causes but also their possible solutions.

Actually, GIS involves multiple disciplines, such as databases, images, applied mathematics, and mathematical models. When students conduct research, they have to process a lot of information; the related software enables them to consolidate their work.

"GIS involves databases, images, applied mathematics and mathematical models. Germany, Switzerland, the U.K., Australia, the U.S. and Canada have long integrated GIS into STEM education."

GIS applications of secondary school students

Six years ago, Hong Kong Education City (HKEdCity) collaborated with Esri China (Hong Kong) to launch Map in Learning (MiL) programme, offering GIS software to primary and secondary school students in Hong Kong free of charge, with a hope that the software can enhance young people's problem-solving abilities. As of late 2021, the MiL programme has attracted more than 220 schools to participate and over 1,700 teachers and students to attend relevant training.

We can see the obvious advantages of this software from the Tung Wah Group of Hospitals Joint Secondary Schools Outstanding GIS Application Competition 2018/19.

This competition was co-organised by HKEdCity and Esri China (Hong Kong). About 100 students from 18 Tung Wah Group of Hospitals (TWGHs) secondary schools participated in the competition.

Champion: Smart use of urban space

The champion was TWGHs Lo Kon Ting Memorial College. The students adopted a geographic theme from secondary school: "Smart use of urban space" to maintain a sustainable urban environment, implying that the study combined the theories they learned with GIS.

They studied the distribution, type, number of users, walking distance, and nearby land use of the open space in Yuen Long, so as to understand what improvements could be made. They proposed to optimise and activate the Shan Pui River which runs through northern and southern Yuen Long, to increase greenery and open space. The construction of recreational trails along the river was also suggested.

During the analysis, the students had to deal with many options and master the professional software ArcGIS Online. It is not an easy task for secondary students, but they demonstrated a strong team spirit, and their never-give-up attitude impressed all of us.

1st runner-up: Rat infestation

In 2018, the world's first case of a human infection with Hepatitis E through a rat broke out in Hong Kong. People worried about the problem. The students of TWGHs Wong Fut Nam College studied the problem in Hong Kong and won the first runner-up prize in the competition.

They examined the Sham Shui Po area to study the links between rat infestation and locations of rubbish bins. The result was displayed on a map and compared with the reference index of rodents in other areas of Hong Kong. Finally, the study made several recommendations, including the best locations to install ultrasonic repellents to reduce the breeding rate of rats by up to 15 %, which is a very practical solution.

2nd Runner-up: charging of electric vehicles

As for the 2nd Runner-up, the students of TWGHs Li Ka Shing College studied the effectiveness of promoting electric vehicles in Hong Kong, particularly in the North District. The students interviewed drivers and found that due to insufficient charging stations and a slow charging speed, owners were discouraged. In the report, the students offered improvement suggestions in the hope of promoting Hong Kong's smart mobility.

Using GIS technology, we can attempt to solve the urban problems by examining the geographical aspects of issues. As Jack Dangermond, the president of Esri, has said: "For the future of GIS, the sky is the limit. It all depends on our creativity to discover its possibilities."

3.8 Outstanding work of tertiary students

The annual Esri Young Scholars Award provides an opportunity for local tertiary students to conduct research in their chosen topics using the geographic information system (GIS). The champion can participate for free in the Esri User Conference held in the United States in July to exchange knowledge and experiences with more than 10,000 GIS experts around the world. However, due to the Covid-19 epidemic in 2020 and 2021, the trip has been postponed while the winners could attend the online event. In addition, the champion, first and second runner-up will win an internship to work at the Urban Renewal Authority (URA), the same as in previous years.

When I saw the award-winning works of the past two years, I can't help but admire the young people's broad visions, their care for society, and their creative thinking.

2021's champion, first and second runner-up are all students from the Department of Urban Planning and Design, Faculty of Architecture, the University of Hong Kong. Their research topics focus on quality of living and mobility which are closely related to all of us; they utilise new perspectives and new data, which is very impressive.

2021 Champion: Closer to nature

The champion is Li Maosu, Eric. He studied how urban housing planning can bring people closer to nature which is of great benefit to people's mental health and their productivity.

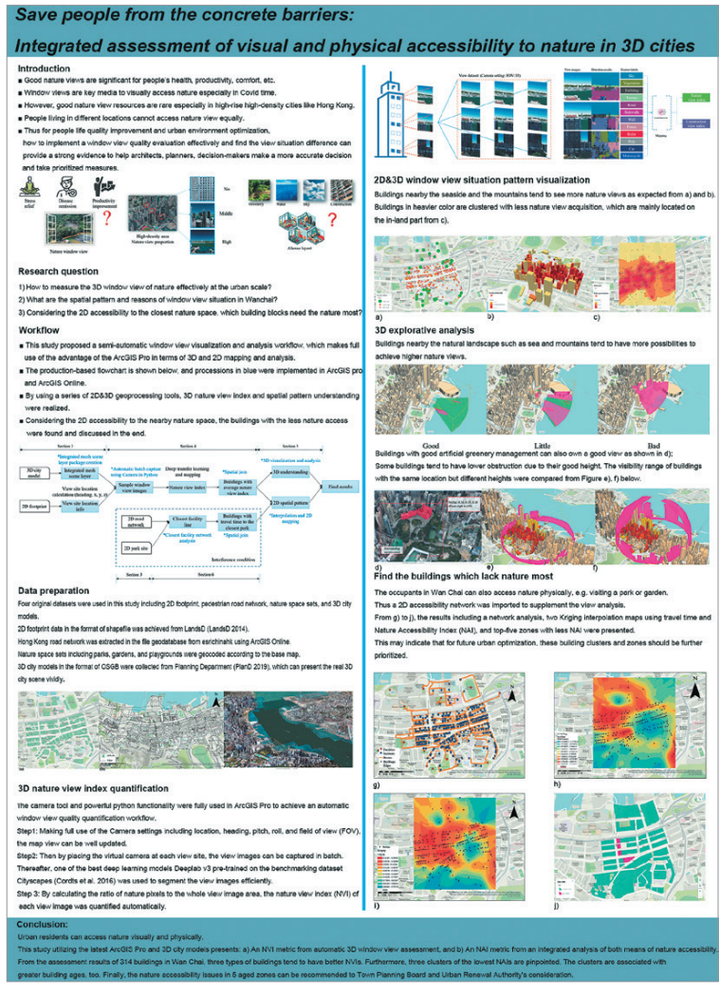
> *"The Esri Young Scholars Award allows undergraduate and graduate students to use GIS to analyse their selected topics and suggest solutions. The diverse themes show that young people care about society."*

Eric chose 314 residential buildings in 43 town blocks of Wan Chai as the research sub-object, covering Lockhart Road, Fleming Road, Jaffe Road, and Johnston Road. There are many old buildings in the mix with 30 to 40-storey new buildings, which block the views of the old buildings. So how to perceive the natural views from every unit on the different floors of each building?

In recent years, the government opened the 3D Pedestrian Network and 3D Visualisation Map datasets to the public for free. The new data makes it possible for people to analyse urban problems with enriched elements.

Eric first used the 3D Photo-realistic Model from the Planning Department and Esri's 3D terrain model to automatically construct a landscape picture from 19,837 windows using deep learning models. Each 3D picture has 89.1 million colour pixels, and the pictures are used to measure the nature view

The 2021 champion Eric Li used the 3D maps to study whether there were natural views from every unit on the different floors of each building in Wan Chai.



index (NVI) in which those closer to parks or units on the higher floors of a building will have a higher score.

Then, he reviewed the walking distance from the buildings with a lower NVI to the natural environment, such as parks and playgrounds, and found that five buildings in the district have both the longest distance from natural scenery, and poor natural views. He suggested the authority to put them in the highest priority for improvement.

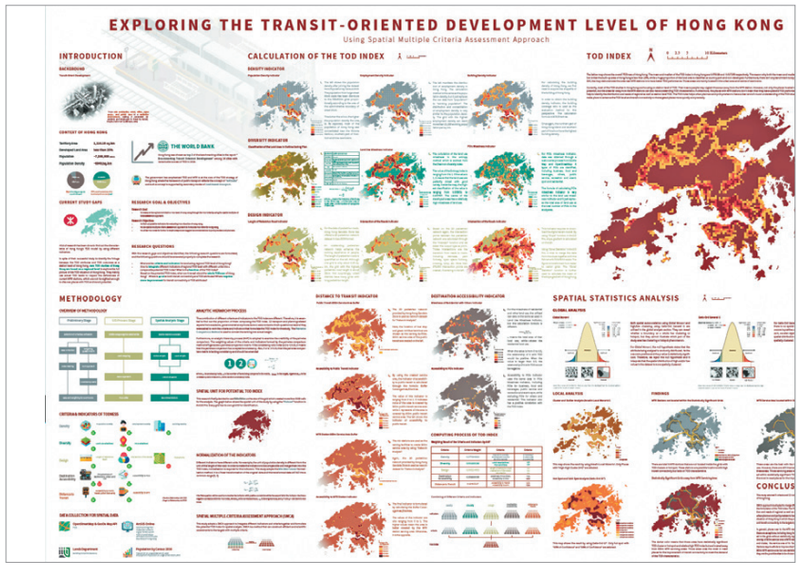
2021 1st runner-up: Blind spots of city planning

Cities around the world have been focusing on transit-oriented development (TOD), which uses public transportation to complement diversified land use, such as commercial, residential, leisure, and so on. By doing so, citizens are encouraged to choose public transportation when commuting to work and school, reduce their dependence on private cars, and also support sustainable development. Hong Kong's urban planning often concentrates around MTR stations, it is ranked third according to the TOD assessment of 14 cities in the world by the World Bank.

Is there any room for improvement? The first runner-up of 2021's Esri Young Scholars Award, Cheng Chi Chiu, David, expanded the scope to review Hong Kong from a regional level. He looked for development opportunities that we might have missed.

David designed a set of measurement indicators with a 5D model as the major framework, including "density" (subdivided into three small indicators of residential population, working population, and building density), "diversity" (commercial, residential, community, industrial, public facilities),

The 2021 1st runner-up David Cheng pointed out that though Heng Fa Chuen, Fo Tan, and Wong Chuk Hang are connected by MTR, the land there is not fully utilised.



"design" (length of pavements, topography, etc.), "destination accessibility", and "distance to transit".

As a result, he found that the area adjacent to the MTR stations of Mong Kok, Sham Shui Po, and Prince Edward have formed the best networks, and they reaped the greatest benefits with the combination of diversified land use and public transportation. On the contrary, although Heng Fa Chuen, Fo Tan, and Wong Chuk Hang are also connected by MTR, the land there is not fully utilised, so he hopes the authorities will improve this in the future.

2021 2nd runner-up: Digitalised geospatial info

The second runner-up, Lui Wing Hin, Daniel, believes that to improve urban development, GIS and building information modelling (BIM) should be combined. The former is good at planning and analysis, while the latter is strong in architectural design and documentation. The combination of the two can improve communication, reduce human errors in data transfer, and promote cooperation between stakeholders.

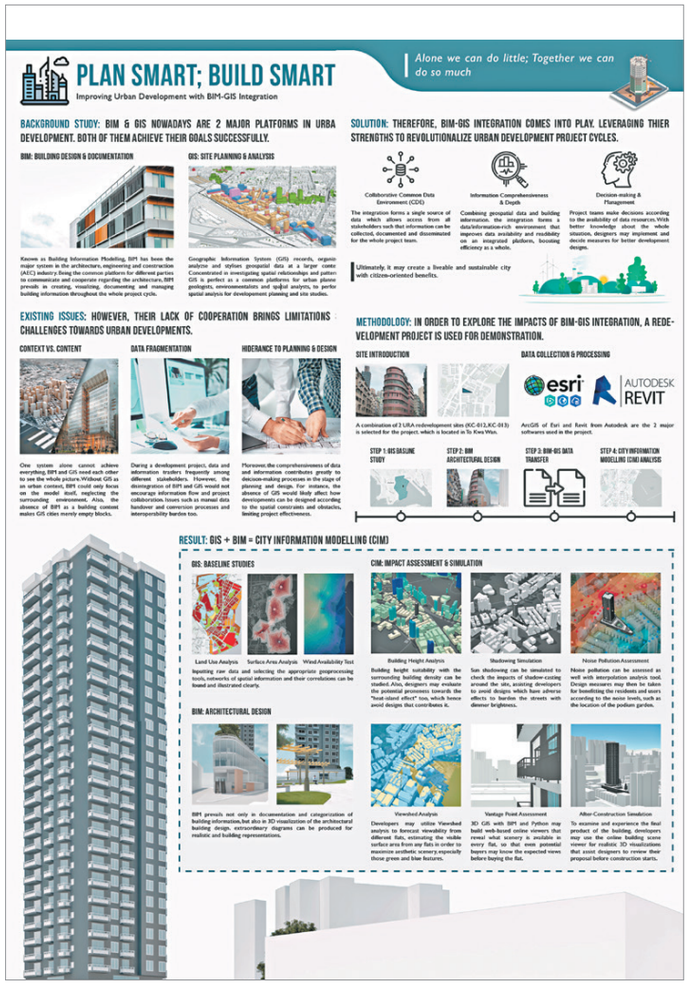
He cited the successful examples of integrating GIS with BIM, such as the Zero Carbon Building and the preservation project of Shanghai Street Shophouses.

Daniel further quoted the Kai Ming Street/Wing Kwong Street development project of the URA in To Kwa Wan as another example that GIS and BIM should be applied in combination. He said that although the buildings are aged, the back alleys are poor in hygiene, and illegal parking is common, the 60-year-old Elver House is very unique for its iconic "corner house" which is worth preserving, and there are many other 6-8 storey buildings which were built in the 1950s and 1960s.

If GIS and BIM are combined, a virtual 3D digital city environment can be constructed, and the optimal height of proposed new buildings, which can then fit in the surrounding environment, can be understood more clearly, and it can avoid the heat island effect. People can also review the "24-hour shadowing simulation" which shows the changes in sunlight at different periods of time, the noise effect with different orientations of buildings, as well as the views from different units.

The Esri Young Scholars Award winners in 2020 adopted diverse topics:

The 2021 2nd runner-up Daniel Lui believes that combining GIS and building information modelling can improve urban development.



from finding the most dangerous road sections to help reduce traffic accidents, and suggesting the best locations for increasing columbaria, to exploring how to promote local eco-tourism.

2020 Champion: Effective way to reduce traffic accidents

The champion of Esri Young Scholars Award, Tsoi Ka Ho, Jason, is a student from HKU's Department of Geography of the Faculty of Social Sciences. Hoping to reduce traffic accidents in Hong Kong, he found that using Junction Blacksites ("blacksites") was insufficient as the focus of prevention by the Transport Department (TD).

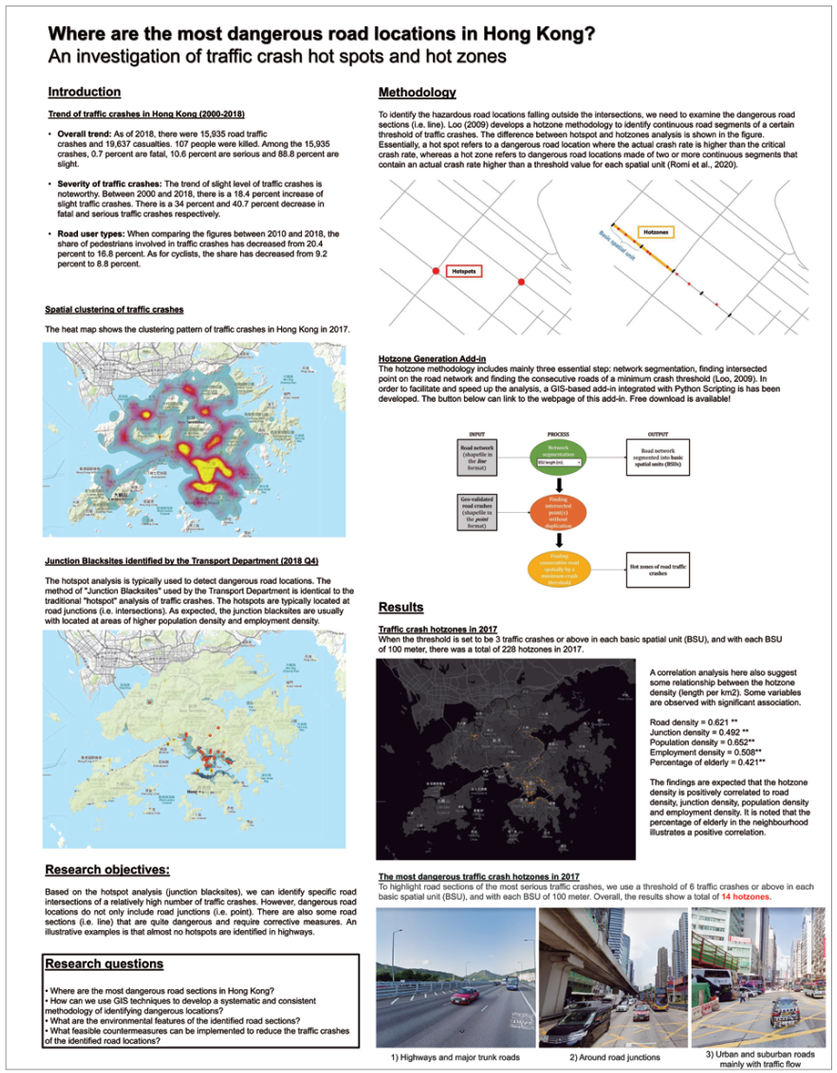
Since 2000, the number of serious casualties has dropped significantly, but the number of minor injuries has increased by more than 18%. Among them, driver injuries accounted for 25% in 2010, but increased to 34% in 2018.

Jason pointed out that the locations of TD's "blacksites" might be the result of a series of events. He wanted to identify the sections of road with inherent problems to make the road improvement measures more effective.

He classified two or more connected road sections where at least three accidents occurred within the past few years as dangerous "hotzones" and analysed them with GIS software ArcGIS. Within 30 seconds, the software organised the data of 15,000 accidents in a year which were then distributed on 4,000 km of roads.

Taking 2017 as an example, the analysis shows that:

The 2020 champion Jason Tsoi identified the most dangerous road locations in Hong Kong, hoping to make the road improvement measures more effective.



Where are the most dangerous road locations in Hong Kong?
An investigation of traffic crash hot spots and hot zones

Introduction

Trend of traffic crashes in Hong Kong (2000-2018)

- **Overall trend:** As of 2018, there were 15,935 road traffic crashes and 19,637 casualties. 107 people were killed. Among the 15,935 crashes, 0.7 percent are fatal, 10.6 percent are serious and 88.8 percent are slight.
- **Severity of traffic crashes:** The trend of slight level of traffic crashes is noteworthy. Between 2000 and 2018, there is a 18.4 percent increase of slight traffic crashes. There is a 34 percent and 40.7 percent decrease in fatal and serious traffic crashes respectively.
- **Road user types:** When comparing the figures between 2010 and 2018, the share of pedestrians involved in traffic crashes has decreased from 20.4 percent to 16.8 percent. As for cyclists, the share has decreased from 9.2 percent to 8.8 percent.

Spatial clustering of traffic crashes

The heat map shows the clustering pattern of traffic crashes in Hong Kong in 2017.

Junction Blacksites identified by the Transport Department (2018 Q4)

The hotspot analysis is typically used to detect dangerous road locations. The method of "Junction Blacksites" used by the Transport Department is identical to the traditional "hotspot" analysis of traffic crashes. The hotspots are typically located at road junctions (i.e. intersections). As expected, the junction blacksites are usually with located at areas of higher population density and employment density.

Research objectives:

Based on the hotspot analysis (junction blacksites), we can identify specific road intersections of a relatively high number of traffic crashes. However, dangerous road locations do not only include road junctions (i.e. point). There are also some road sections (i.e. line) that are quite dangerous and require corrective measures. An illustrative examples is that almost no hotspots are identified in highways.

Research questions

- Where are the most dangerous road sections in Hong Kong?
- How can we use GIS techniques to develop a systematic and consistent methodology of identifying dangerous locations?
- What are the environmental features of the identified road sections?
- What feasible countermeasures can be implemented to reduce the traffic crashes of the identified road locations?

Methodology

To identify the hazardous road locations falling outside the intersections, we need to examine the dangerous road sections (i.e. line). Loo (2009) develops a hotzone methodology to identify continuous road segments of a certain threshold of traffic crashes. The difference between hotspot and hotzones analysis is shown in the figure. Essentially, a hot spot refers to a dangerous road location where the actual crash rate is higher than the critical crash rate, whereas a hot zone refers to dangerous road locations made of two or more continuous segments that contain an actual crash rate higher than a threshold value for each spatial unit (Romi et al., 2020).

Hotspots

Hotzones

Basic spatial unit

Hotzone Generation Add-in

The hotzone methodology includes mainly three essential step: network segmentation, finding intersected point on the road network and finding the consecutive roads of a minimum crash threshold (Loo, 2009). In order to facilitate and speed up the analysis, a GIS-based add-in integrated with Python Scripting is has been developed. The button below can link to the webpage of this add-in. Free download is available!

INPUT

PROCESS

OUTPUT

Road network (shapefile in the .shp format)

Network segmentation

Road network segmented into basic spatial units (BSUs)

Geo-validated road crashes (shapefile in the .point format)

Finding intersected point(s) without buffer

Finding consecutive road spatially by a minimum crash threshold

Hot zones of road traffic crashes

Results

Traffic crash hotzones in 2017

When the threshold is set to be 3 traffic crashes or above in each basic spatial unit (BSU), and with each BSU of 100 meter, there was a total of 228 hotzones in 2017.

A correlation analysis here also suggest some relationship between the hotzone density (length per km2). Some variables are observed with significant association.

Road density = 0.621 **
Junction density = 0.492 **
Population density = 0.652**
Employment density = 0.508**
Percentage of elderly = 0.421**

The findings are expected that the hotzone density is positively correlated to road density, junction density, population density and employment density. It is noted that the percentage of elderly in the neighbourhood illustrates a positive correlation.

The most dangerous traffic crash hotzones in 2017

To highlight road sections of the most serious traffic crashes, we use a threshold of 6 traffic crashes or above in each basic spatial unit (BSU), and with each BSU of 100 meter. Overall, the results show a total of 14 hotzones.

1) Highways and major trunk roads

2) Around road junctions

3) Urban and suburban roads mainly with traffic flow

- 228 hotzones were found, with a total length of 61.8 kilometres and an average of 13 crashes in each hotzone;
- The highest crash density is 17.5 crashes per km. This is located at Tai Mei Tuk Road;
- There are more accidents within the area where elderly people are concentrated.

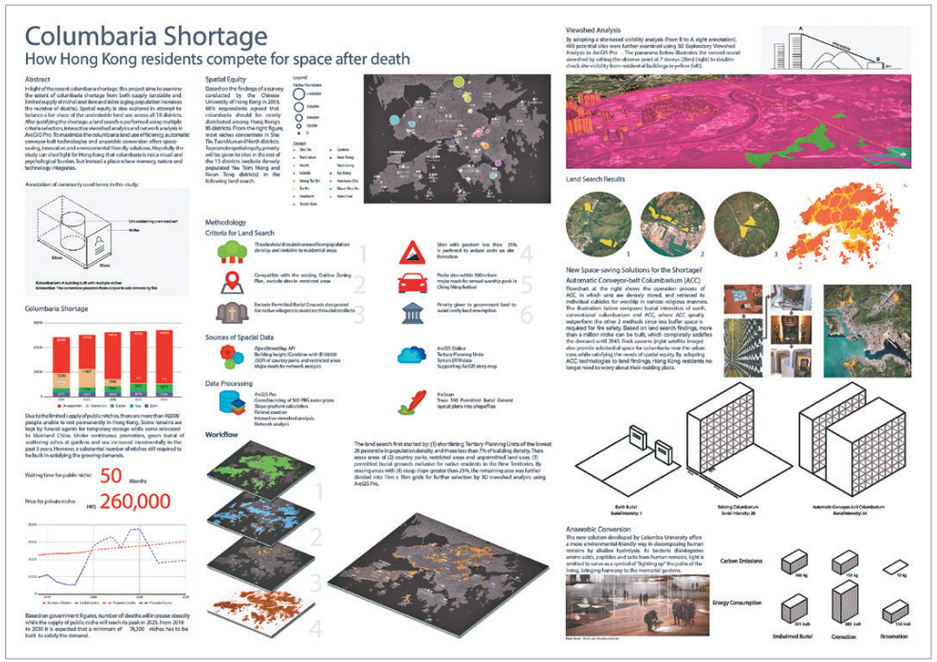
As a result, he identified the 14 most dangerous road sections with at least six accidents within 100 metres. They are widely distributed on King's Road, Kwun Tong Road (near Choi Hung and Kwun Tong MTR station respectively), Pui Ching Road near Ho Man Tin, Fanling Highway and Ting Kok Road. Many of them are not on the TD's blacksites list. There are different problems, such as people and vehicles competing for the road, intersections being too close to each other, and some have problems of speeding vehicles. The authorities should carry out improvements according to the actual situation.

2020 1st runner-up: Create one million niches

The 1st runner-up of 2020's Esri Young Scholars Award, Lam Tsun Yeung, Justin from HKU's Department of Urban Planning and Design of the Faculty of Architecture. He used spatial data analysis to find new locations for columbaria that meet the requirements of all parties and offer space-saving ideas.

In 2018, the number of unplaced ashes of the dead was huge, reaching 43,000, and troubling many families. The authority plans to build 490,000 columbarium niches in the future, mainly in Tsang Tsui, Tuen Mun and Sandy Ridge, Fanling. Shek Mun and Chai Wan are more easily accessible, but it is anticipated that the residents in the vicinity will object to the idea.

The 2020 1st runner-up Justin Lam tried to find new locations for columbaria to meet the future needs.



Hong Kong's population is ageing, the government expects that green funerals, such as memorial gardens, will increase from 16% now to 26% in ten years, but there is still a need to add more than 74,000 slots.

Where does the space come from? Justin found suitable places in 13 districts based on the following six criteria:

- A location with relatively small population and not visible to residents (based on the height of the seventh floor);
- The land slopes are less than 25 degrees, reducing the cost of levelling works;
- In line with the Outline Zoning Plan, restricted areas such as country parks and military land are avoided;
- It is best to be within 500 meters from the main road to facilitate Ching Ming worship;
- Staying clear of existing approved funeral areas to avoid disputes with inhabitants;
- Use government lands as much as possible to avoid land resumption cost.

After analysing with GIS software ArcGIS, he successfully found 19 government lands with a total area of 43 hectares. These include:

- Ta Kwu Ling (11 hectares): 2 to 5 minute drive from Lung Shan Tunnel of Tai Po;
- Tuen Mun (14 hectares): 10 minute drive from Tuen Mun railway station;
- Tai O (4 hectares): 7 minute walk from Tai O bus terminal.

In addition, rock caves are also considered. The Civil Engineering and Development Department has identified five cavern sites with a total of 402 hectares. However, due to the high cost of surveying and construction, they are reserved as a second choice.

In fact, both Tokyo and New York are facing a columbaria niche shortage problem as well. These cities use technology to make up for their

insufficiency. For example, compressing the storage space of the niches to double the capacity, and the urn will be transported by conveyor belt during worship. The worship places are individually separated and decorated according to different religions.

In this way, the capacity of the proposed 19 columbaria can be doubled to more than one million niches, which is enough for use till 2043.

2020 2nd runner-up: Eco-tourism in Hong Kong

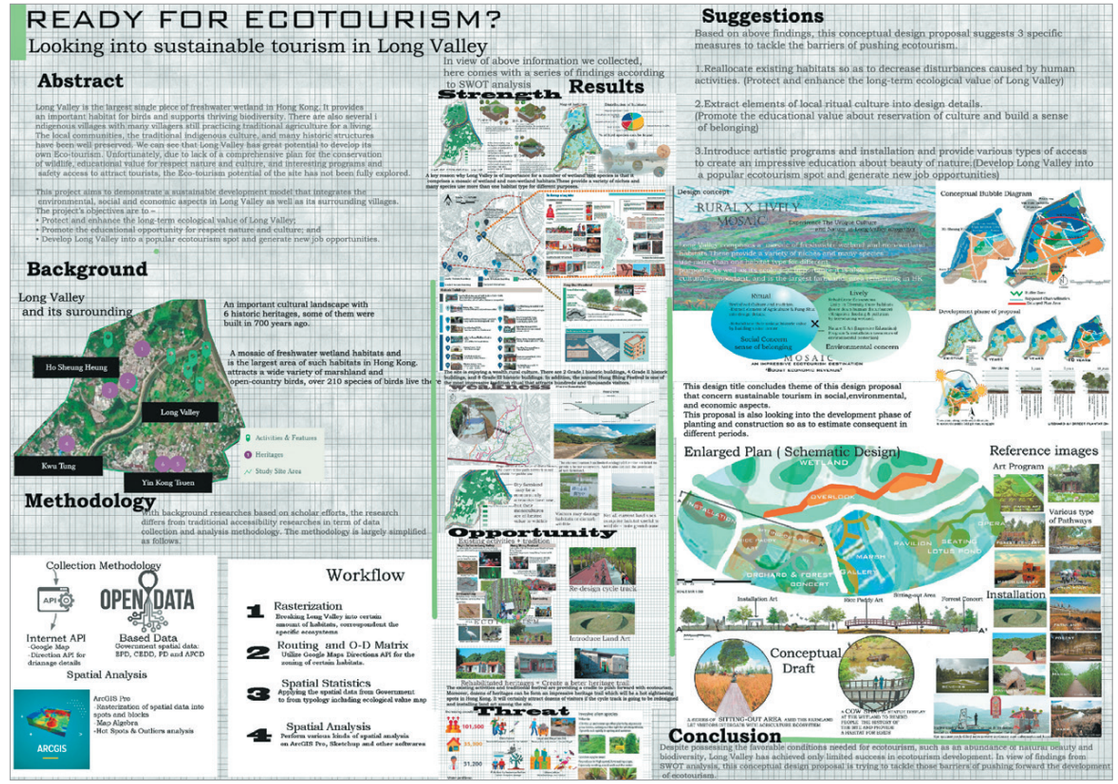
The 2nd runner-up of 2020's Esri Young Scholars Award Chan Tsz Suen, Joe, is a student of the Department of Environment of the Faculty of Design and Environment, at the Technological and Higher Education Institute of Hong Kong. He found that Hong Kong has a rich biodiversity with a vast countryside, both of which have great potential for the development of eco-tourism. He wanted to study its feasibility.

Eco-tourism emphasises the preservation of nature and local culture, and respects the lives of local inhabitants.

Joe selected Long Valley as the research location because of its convenience in terms of transport, it takes only half an hour to reach the place from Sheung Shui MTR Station. The site was originally an enormous piece of agricultural land, and is now home to more than 210 freshwater wetland species such as bitterns, black-winged stilts, and crakes. Among them, 25 species of birds are under protection.

In addition to natural species, there are two Grade I historic buildings, four Grade II historic buildings, and eight Grade III historic buildings.

The 2020 2nd runner-up Joe Chan explored the potential and feasibility for the development of ecotourism.



What's more, the annual Hung Shing Festival is one of the most impressive traditional rituals. The festival is held by the Village Council to celebrate for five days and nights, along with traditions like firecrackers, a lion dance, Cantonese opera, and a big bowl feast. Every year it attracts hundreds and thousands of visitors. At the same time, many local inhabitants still rely on farming. The place, together with Ho Sheung Heung and Kwu Tung nearby are extremely rich in natural and cultural elements, they have great potential for the development of eco-tourism.

However, the population here is estimated to increase from 80,000 today to 100,000. Urbanisation, pollution, and human activities will inevitably affect the natural ecology. Moreover, there is no buffer zone between cultivated land, wetland, and housing, and its land use requires much consideration.

After using the GIS software ArcGIS to consolidate the data, Joe made a number of creative suggestions, including migrating the current species to avoid interference by human activities, so as to preserve the long-term ecological value of Long Valley; injecting the cultural elements of local inhabitants into the design to promote a conservation culture; adding artistic elements to promote the appreciation of the beauty of Long Valley, and to create employment opportunities.

As Joe said, developing eco-tourism will help build Hong Kong into a “more diverse, resilient, and unique” future city.

Summary

Geographic information is valuable and marketable. Young people in different regions of the world use GIS to transform spatial insight into applications for enhancing mobility, business planning or disaster management. Young people in Hong Kong have also demonstrated their talent to improve the quality of life of the community with spatial intelligence, from preventing rodent infestation, making good use of open spaces, improving road design and urban planning, to selecting niche sites.

Hong Kong's digital transformation

04

In the post-epidemic era, people's lives have undergone a paradigm shift and a rapid digital transformation of which GIS plays an indispensable role. The government should actively promote GIS to improve governance, city planning and communications with its people.

4.1 High-level administration within government for smart city upgrade

In March 2021, Singapore's Minister for Foreign Affairs, Dr Vivian Balakrishnan delivered an impressive opening address which has inspired us to think about the way forward for Hong Kong's smart city.

At a geospatial and location intelligence conference held in Singapore, Dr Balakrishnan, who is also the Minister-in-charge of the Smart Nation Initiative, talked about how geospatial innovation has become "a critical dimension of Singapore's Smart Nation journey", and that the resulting "great synergy" made it more effective in rolling out the smart city initiatives. These viewpoints are not new. However, it was refreshing that he did not talk about policies or funding, rather he quoted real-life examples to illustrate how geospatial data could benefit the community.

Public-private-people partnership creates great synergy

Take the rescue of cardiac arrest patients who require urgent first aid as an example. There is an existing myResponder app developed by the Singapore Civil Defence Force which connects the ride-hailing company Grab and CPR-trained volunteers. When the drivers are alerted by the myResponder app, they can rush to the rescue. By the beginning of 2021, 50 ride-hailing vehicles have been equipped with automated external defibrillators (AEDs) and first aid kits, and more than 60 private-hire drivers have been trained

> *"For a smart city to succeed, the government should set up a high-level organisation to mobilise various departments and keep up with market demands by partnering with the business community."*

Public-private-people partnership with spatial data creates great synergy for the rescue of cardiac arrest patients.

Source of info: Singapore Civil Defence Force, Smart Nation Singapore

to be lifesavers. At the same time, under the Singapore Land Authority, GeoWorks (similar to Geospatial Lab in Hong Kong), aiming to support geospatial industry to promote innovation and business growth among startups and corporations, has a drone company that could assist the rescuers by leading the way to find patients as quickly as possible.

The collaborative approach between the government and the private sector, as well as the general public, using spatial information can create "great synergy", according to Dr Balakrishnan.

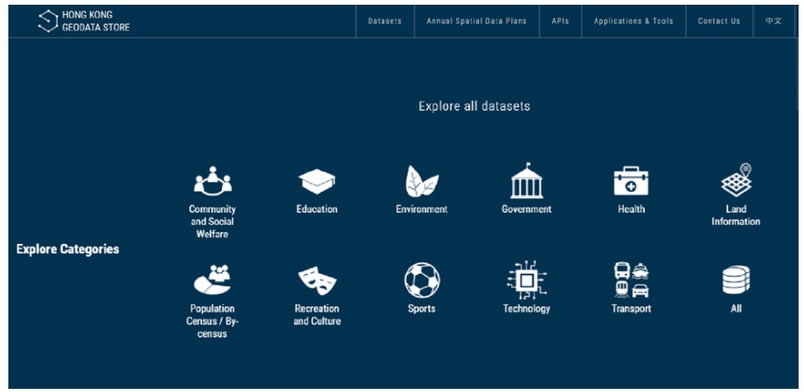
Another example is a geospatial urban planning system, the ePlanner developed by the Urban Redevelopment Authority (URA) which collects spatial data from different agencies to optimise the decisions in land use planning. The system is also deployed in healthcare and community organisations for better resource allocation. For neighbourhoods with large elderly populations, for instance, more appropriate health and social programmes can be planned.

Real-time spatial data has a wide range of usage, such as transportation, ride-sharing, logistics, and food delivery services. These geospatial industries were valued at S$170 million (about HK$980 million) in 2009, and have tripled in 10 years to S$500 million (about HK$2.9 billion). According to Dr Balakrishnan, in order to provide the foundation for the private sector to innovate and develop new solutions, the government should build digital platforms "to facilitate geospatial data sharing across both the public and private sectors". The above examples clearly show that public-private collaboration can produce "great synergy".

Hong Kong: Excellent infrastructure but lack synergy

In recent years, the Hong Kong government has also been working hard to promote the opening and sharing of geospatial data. The Transport Department's HKeMobility app has added the real-time arrival data of the Kowloon Motor Bus, Long Win Bus and 70 green minibuses in March 2021, with the Light Rail added in the following month. Singapore is so proud of its single data platform OneMap3D, Hong Kong actually has a similar 3D city map, which was established by the Lands Department a few years ago. The 3D Visualisation Map displays topographical and exterior features of terrain, buildings, and urban facilities, including more than 2,000 footbridges, 400 subways, and footways enabling wheelchair access at over 2,100 public facilities and over 1,300 public access lifts. These 3D maps have been available free of charge to public since 2020.

Hong Kong is not inferior to the neighbouring countries in becoming a smart city, especially in spatial data infrastructure.



Source of info: Hong Kong SAR Government

It can be said that Hong Kong is not inferior to the neighbouring countries in becoming a smart city, especially in infrastructure. However, we have a fatal flaw, that is, many projects are not related to each other, making it difficult to produce synergy.

High-level body for effective coordination

What is the key to Singapore's success? In a media interview, Dr Balakrishnan mentioned why Singapore formed a Smart Nation and Digital Government Office (SNDGO) in 2017, in addition to the Smart Nation Initiative. Both of them are directly under the Prime Minister's Office to ensure different government systems can be integrated and interconnected to implement the smart nation policies in a top-down approach.

In early 2016, the Smart City Consortium (SCC), which I founded, mentioned in its first advisory paper to the government that a high-level administration should be set up to "co-ordinate the major tasks, including the standardisation of data and the setting up of a framework to develop guidelines for data definition, collection and processing." In addition, it also has to "identify and review relevant laws and regulations for the development of technologies, usage of data, and particularly the protection of privacy and personal information."

To this day, we believe that these suggestions are still appropriate and are becoming more urgent. Otherwise, despite advanced technology and sufficient funding, it will still be difficult to achieve the expected results.

The Chief Executive or the Chief Secretary for Administration should lead this high-level administration to mobilise various departments so that the entire government can move forward in unison and all departments can coordinate with each other. At the same time, the new body should consult private organisations and business sectors so as to be close to the market demand.

Through this top-down approach with public-private collaboration, the whole of government can move forward in a concerted manner, and Hong Kong can maximise the effectiveness of open data for spurring the growth of the new economy.

To release the power of data, a complete ecosystem is needed. In this regard, governments have to ensure the following measures are in place:

Fairness	Open data should not only benefit big corporations but also the general public and SMEs.
Continuity	Open data is a long term investment as it requires upgrading on a regular basis.
Security	Protection of network security and personal data privacy is a must.

Source of info: sz.gov.cn

4.2 $500 million City I&T Grand Challenge opens unlimited opportunities in spatial information

> *"Through competition, participants can explore innovative applications of spatial data, from finding missing elderly people, and tracking the location of minibuses, to disaster relief, and urban planning."*

Spatial data has great commercial and practical value which Hong Kong has yet to realise. Why doesn't the government consider making use of the HK$500 million hackathon proposed in 2018 by the Chief Executive to encourage the real-life application of this data?

British consulting firm Oxera estimates that geospatial data generated up to US$270 billion (over HK$2 trillion) revenue globally each year, and expects the figure to grow by 30 % annually.

Huge value of geospatial data

This trillion-dollar business opportunity is not a distant dream. Take a look at the *Hurun Global Unicorn List 2020* which lists companies ranging from logistics and delivery services to autonomous driving. The backbone of these companies' operations is geospatial data. The total valuation of the 16 Chinese unicorns in the logistics sector alone represents US$68 billion (about HK$530 billion), more than a quarter of the expected global market value of geospatial data. Without geospatial data, they couldn't exist.

The unicorn list covers private companies established after the year 2000 with a valuation of at least US$1 billion. In 2020, 586 unicorns from 29 countries around the world are on the list, covering industries like financial services, retail, logistics, automobiles, media and entertainment, and healthcare.

For many logistics companies, geographic information is not a mere electronic map but an important tool to ensure the efficiency of transportation fleets. With the prevalence of the "stay-at-home economy" and online shopping, these logistics companies use a geographic information system (GIS) and a global positioning system (GPS) to organise their fleets, plan the shortest delivery routes, and keep track of their truck locations to deliver goods to customers in a quick and secure manner.

Deliveries are affected by road conditions so it is important to have real-time integrated geographic information. That information may come from surprising places.

The Swedish startup Mapillary crowdsources street-level images and uses

artificial intelligence to identify road signs, traffic lights, and lanes, which it then uses to form 3D maps. Today, more than 1.5 billion street images from around the world have been collected.

Blank zones

In addition, accurate address is also an indispensable part of geographic information. Living in Hong Kong, we are used to a generally comprehensive address system. However, nearly 75 % of the world (over 135 countries) lacks a unified address system. Some areas have none at all. This can cause property disputes, difficulty in receiving mail and relief supplies, not to mention the challenge of tracking the Covid-19 epidemic.

Even if there is an address system, accuracy is always a problem. In the rural areas of Hong Kong, for example, the address displayed uses the "lot number", which is the number for the land as recorded in the Land Registry, instead of using common information such as street name and house number. This can create blind spots in delivery services. In the United Kingdom, 0.5 % of all deliveries fail due to poor addressing. This cost businesses £1.6 billion (about HK$16.3 billion) in 2018. UPS believes that if each of their drivers can save one mile of unnecessary travel, they can save up to US$50 million (about HK$390 million) annually.

Truly global coverage

Whenever there is difficulty, there is a business opportunity. What3words, founded by a British musician and a mathematician, divides the world into 57 trillion squares of 3 metres by 3 metres, and uses three unique and randomly selected words to represent each location instead of the 16 numbers as used in the global grid system. For example, "headrest.these. energetic" is the location of the Hong Kong Convention and Exhibition Centre while "measures.worlds.cushy" represents the location of my company. It covers every corner of the world, including the countryside, in more than 45 languages. Currently, Mercedes Benz and Mongolia have adopted this mobile application.

Geospatial matters for Covid

Geospatial data and GIS can also enable a better understanding of infectious diseases. That's why the Hong Kong Polytechnic University, with government funding, has established a database of Covid-19 genes through the use of GIS. This can be used to identify the source of community transmission through genome-wide sequencing, together with the analysis of patients' onset of symptoms, location and travel records.

Obviously, spatial data has great commercial and practical value, but the general public in Hong Kong is rarely aware of it. As suggested by the Innovation and Technology Bureau, the best way to promote spatial data is to apply it in real life to improve social welfare.

How can this be done?

In the *2018 Policy Address*, it was proposed to allocate HK$500 million to organise a territory-wide hackathon, the City I&T Grand Challenge every year for the next five years to promote science education, and encourage all sectors to use innovation and technology to solve problems in everyday life. The scale of the hackathon is unprecedented, we were all excited at that time; but the event could only be held in 2021.

From planning travel routes, finding lost elderly, tracking the real-time location of buses, and identifying roads that require repair, to natural disaster relief in our neighbouring countries (such as ASEAN countries), 3D city planning, mapping natural resources, and guiding future autonomous vehicles, there are lots of topics related to geospatial data that the authorities can use as the theme for the competition. I believe that there are masters among us, and participants' innovative ideas can greatly promote the development of technological solutions, and help the local innovation and technology sector to open up local and overseas markets.

4.3 Smart city strategies should be sustainable

The government will soon announce the *Smart City Blueprint for Hong Kong 2.0.* It is time for us to review the progress of the first blueprint and look forward to the future.

The first blueprint contains 70 measures from open data, and smart lampposts, to the Faster Payment System. Take open data as an example, at the end of 2019, the government's open datasets increased to nearly 3,900. Most of them are machine-readable and connected to geographical locations, this is called "CSDI-ready" which promotes innovation (such as startups developing applications) and research.

However, the problem is that most departments concentrate on their internal functions and neglect connecting their data with others. This arises from an individual department's objective of achieving fast results using information technology rather than allocating resources on collaborating with other departments, which may take more effort to realise their objectives.

Apparently, the approach towards smart city development among European countries, the United States and other places is very different from ours. Earlier, I attended the Smart City Roundtable jointly organised by the Smart City Consortium, the Hong Kong General Chamber of Commerce, and the Jockey Club Design Institute for Social Innovation of the Hong Kong

> *"Smart city development requires a holistic strategy so as to generate synergies, it should not be treated as an individual project."*

Polytechnic University. I was impressed by the speech delivered by Mr Marcos Chow, Head of Technology Enablement, Hong Kong; Partner – Smart City Group, KPMG China. He talked about the development of global smart governments, and quoted that many countries all over the world have adopted smart city as a sustainable development strategy, which could improve people's quality of life and protect the environment. Yet, Hong Kong only treats smart city as information technology, and often focuses on the basic level of development such as speed of network.

For example, in 2017, several Finnish universities cooperating with Nokia's research institute invested US$25.4 million (nearly HK$200 million) to carry out 6G mobile network research. With reference to 5G which took nine years from research to commercialisation, it is expected that 6G will be available by 2027. If the 6G research is successful, Finland will be able to regain its leadership in mobile communication.

Today, every country, including China, is actively pursuing clean energy, South Korea and Japan are also competing in this arena too.

It was reported that the Tokyo Metropolitan government invested 40 billion yen (approximately HK$2.8 billion) in the R&D of hydrogen as a clean energy, which was supposed to be used in the Tokyo's Olympic Games with 6,000 hydrogen-powered cars.

South Korea followed suit. In 2018, the Ministry of Land, Infrastructure and Transport selected three cities to test hydrogen for heating and cooling, electricity, and fuelling buses and private cars. The government will spend more than 230 billion won (over HK$1.5 billion) to subsidise vehicles and hydrogen charging facilities. South Korea is striving to expand hydrogen fuel to 30% of the country's cities by 2040; hydrogen is expected to become a new driving force for South Korea's economy.

Others like the Dubai government's full operation of a blockchain, which enhances efficiency and promotes industrial development. The country also hopes to take the lead in the international arena. While Tel Aviv, Israel consolidated and displayed useful information on a mobile application for the convenience of the public, such as city activities, restaurants, transportation, parking spaces, hazard alerts, and special notices, etc.

The above new measures share the same characteristics: they benefit the entire society; they need the cooperation of the government, public and private organisations and citizens; and they often promote economic development. When a country successfully demonstrates its use of innovative technologies, naturally it will have a better chance to export its service and expertise to other places, creating business opportunities.

Therefore, I look forward to the forthcoming *Blueprint 2.0*, which should aim at sustainable and long-term development for Hong Kong.

4.4 Shenzhen's road to digital transformation

During the Covid-19 epidemic in 2020, education, work, meetings, shopping, and entertainment have mostly been moved online. This new normal is called "digital transformation". Governments around the world have implemented various measures to accelerate this digital transformation, for which data, especially geographic information that connects people and places, has become increasingly important.

For example, New York's *Open Data Law* has been well known. The city stipulated that by the end of 2018, all public data must be disclosed on a single government platform to increase governance transparency and spur the new economy. Singapore is committed to digital readiness and encourages people to embrace artificial intelligence. Through the analysis of anonymous mobility data, the number of crowded buses was reduced by more than 90%. Amsterdam has also opened up spatial data, including real-time public transportation and road condition information, to promote innovation and entrepreneurship, in particular, with the younger generation.

Our neighbour Shenzhen is also outstanding in the process of digital transformation. There has been a total of over 24,000 open data items on the open data platform of the Shenzhen Municipal People's government since 2016, and opening data has gradually become the driving force of its smart city development. Shenzhen was ranked first in the *2020 China*

> *"Shenzhen encourages government departments to open up data through competitions, unleashing the potential of data, and stimulating social innovation."*

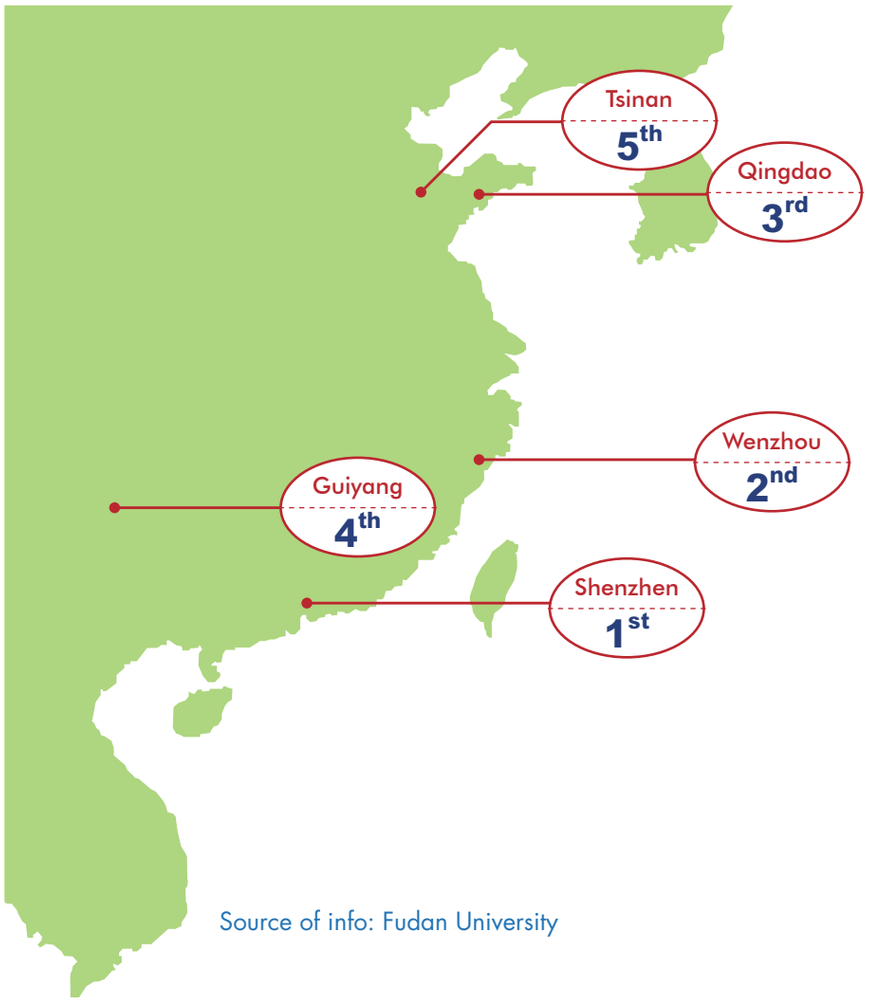
Open Data Index (including sub-provincial level), and was ranked the first in utilisation level.

The index mainly evaluates four aspects, namely readiness (regulations, policies, organisation and implementation, standards and norms), platform (construction of open data platform), data (open data quantity) and utilisation (output of open data).

Shenzhen's achievement can be attributed to the efforts in many aspects. The key is the *Shenzhen Open Data Innovation Contest* ("SODIC") held every year since 2019, which provides a chance to solicit innovative application solutions and algorithm models of open data from universities, research institutions, data analysis companies, and developers around the world. In 2020, more than 1,800 teams participated in the event, which pushed the government departments to further open up data, realise the potential of data, and stimulate social innovation.

In 2020, the majority of winning entries of SODIC were related to geospatial

Shenzhen was ranked first in *2020 China Open Data Index.*



Source of info: Fudan University

information. They cover a wide range of topics including epidemic prevention and urban management (water quality monitoring; water supplies network; planning, execution and post-event assessment); economic development (tourism collaboration, location selection of stalls, marine ranching management); and even mobility planning (helping citizens avoid crowds or long waiting times during peak hours in different scenarios, such as in subways, emergency rooms, and when handling government affairs).

In term of competition, Shenzhen promotes creativity, makes good use of spatial information, and releases the potential of data. By doing so, the city has out-performed others in digital transformation.

As for Hong Kong, in the past few years, the government has committed to opening up data and actively developing geospatial infrastructure, but we are still relatively passive in promoting the application of data. I hope that the authorities can learn from the experience of other places to speed up our digital transformation.

4.5 Digital transformation in post-Covid era

> *"The epidemic has accelerated the global digital transformation, GIS which analyses the relationship between people and places, is an important component of digital transformation."*

Today, many authorities use geographic information to drive economic development, mitigate the impact of climate change, and promote high-tech applications such as 5G and unmanned driving. Therefore, geospatial data is indispensable as raised in the *Transforming Our World: the 2030 Agenda for Sustainable Development* of the United Nations. To better utilise these data, the geographic information system (GIS) is essential for aggregation, analysis, storage, visualisation, and the sharing of various data which include LiDAR for measuring distance and ranges, point cloud for producing 3D models, voxels for measuring ecological marine units, as well as low Earth orbit imagery, building information modelling (BIM), the real-time internet of things (IoT) and more. This greatly helps decision-making.

Previously, the 230-year-old Ordnance Survey (OS) in the United Kingdom published a research report which pointed out that governments around the world were increasing their investment in geographic information because the economic return could reach 3.2 times the cost. In terms of government efficiency, OS estimated that the benefits from saved time on the global scale would be US$17.3 billion (about HK$135 billion).

The OS report cited many cases in developing countries, such as Iran's choice of a new hospital site in the western city Kohdasht City. Many factors, including population density, proximity to residential areas and other hospitals, air quality, topography, and the transportation network were taken into consideration by the authorities. Researchers then used GIS and integrated opinions of medical experts to make recommendations. While the Cape Verde in Africa also used GIS instead of paper to conduct the census, it reduced manpower usage by 50%, and took 40% less time, cutting the total time spent from months to weeks.

At the same time, advanced economies such as Canada have benefited many industries through improved geographic information, including energy, transportation, construction, agriculture, utilities, public administration, and more, resulting in a 1.1% GDP increase. A similar study carried out in Australia identified a similar result of up to 1.2% GDP increase.

Using GIS has significant benefits in improving government efficiency and saving expenses. Consulting firm McKinsey found that GIS has been used broadly in various applications, such as Singapore's aim to increase citizens' book borrowing from public libraries, the selection of the best childcare centre site in Uji in Japan, and assessing the relations between

patients suffering from diabetes and obesity with grocery store catchments in New York, the United States. The study surveyed more than 30 cities, and interviewed a number of private organisations and academic experts.

During the epidemic in 2020, education, work, meetings, shopping, and entertainment have mostly been moved online. This new normal is the era of "digital transformation", in which data, especially geographic information that connects people and places, has become increasingly important. Geographic spatial infrastructure such as GIS is regarded as an important component of digital transformation.

As geospatial data is useful for better city governance, I hope that the Hong Kong government will be more active in promoting the opening and application of these data in order to improve the efficiency of urban management.

4.6 Next level of smart city development for Hong Kong

The long-awaited *Smart City Blueprint for Hong Kong 2.0* ("Blueprint 2.0") was launched in December 2020. There are 130 projects this time, including 70 projects first mentioned in the first blueprint in 2017. It is indeed encouraging with the number of initiatives having been doubled. However, under the fierce global competition of today and coupled with the Covid-19 epidemic which has seriously hit the local economy, we need to move quickly.

Therefore, I would like to raise the following questions regarding the *Blueprint 2.0,* especially from the viewpoint of innovation and technology:

1) Open data from private organisations

In July 2020, the Secretary for Innovation and Technology responded to questions from members of the Legislative Council that apart from continuing to open up government data, the government would continue to encourage private organisations such as car parks to follow suit. In the newly launched *Blueprint 2.0*, the government repeated the same statement. Can the government set specific targets with certain check points in a timetable so that people can trace the progress of work, without fearing empty promises?

> *"The government should propose specific measures and a timetable to encourage public and private organisations to open up data, so that people can understand the effectiveness of their work."*

2) The spatial data sharing platform

The Common Spatial Data Infrastructure (CSDI), a one-stop data supermarket planned for official launch in 2022, will facilitate the development of innovation and technology. At present, the Lands Department has set up a convenient and easy-to-use online map for nearly 100 public facilities, which has been well received.

To make CSDI a success, the opened data should comply with two basic principles as follows:
(1) in a machine-readable format; and
(2) linked to spatial and geographical location.

Therefore, the government should announce which departments and what datasets have been compiled in the past 18 months; and their plans in the coming year. From such, we can see the joint efforts between various government departments, and public and private organisations, which can then enable us to enrich the content of our data platform accordingly, and at the same time encourage connections with the public.

3) Interactive Map Dashboard

When Covid-19 broke out in early February 2020, rumours spread everywhere. Our group of information technology (IT) volunteers assisted the government in launching an interactive map dashboard of the epidemic. The map and figures make it easy for the public to understand the latest situation and grasp accurate information, it was well received by the public.

Dashboards have been added to the Blueprint *2.0 website* according to each of the smart city categories which are mobility, living, environment, people, government and economy, but they do not completely fulfil the objectives of *Blueprint 2.0*.

For example, the objectives of the "Smart People" measures are to promote STEM (science, technology, engineering and mathematics) education, enhance scientific research capability, and promote entrepreneurship and innovation. However, only "Number of Persons Engaged Discharging Information Technology-Related Job Duties by Educational Attainment" and "Number of R&D Personnel" on the dashboard are relevant, others like "Educational and Training Institutions by Level of Education" are clearly not.

May I suggest the following information be included on the dashboard:

We can review the following KPIs regularly to determine if our smart city development is on the right track:

Information and communication technology (ICT)
No. of persons employed in ICT sector (increase and decrease in high-tech industries such as electronics, biotechnology, telecommunications, as well as non-ICT companies)
No. of students enrolled in STEM courses in post-secondary education and the ratio of males to females
No. of ICT/knowledge workers incoming from overseas and outgoing to other places
No. of scientists, researchers and engineers
Innovation ability
Detailed information of each youth entrepreneurial fund and scheme, such as investment amount, no. of participants, no. of new startups and job positions
Subsequent success rate: the company lasting for several years or has been acquired
Re-industrialisation: investment, productivity, income, job vacancies
No. of major scientific and technological projects, no. of successful patent applications
Investment in scientific research by ICT and non-ICT industries

Ideally, the above information will reflect the situation of the past 5 to 10 years, allowing people to view the changes. As such, the dashboard not only facilitates the public keeping abreast of the latest developments in innovation and technology, but it also measures whether the local economy matches the ideal structure of the innovation-driven new economy.

In this way, we can work in a concerted manner to promote Hong Kong's innovation and technology and the new economy. This will help promote public participation and take Hong Kong's smart city development to the next level.

4.7 Spatial data for enhancing city's competitiveness

The Geospatial Commission of the United Kingdom previously commissioned a consulting company to undertake a detailed economic study on the size, features and characteristics of the U.K. geospatial or location data market, and how these data can promote the economy.

The report is also inspiring for Hong Kong and our emerging geospatial data market.

U.K. geospatial data values HK$110 billion

The report firstly pointed out that their "geospatial data market" has three characteristics:

1) It is an ecosystem rather than a traditional market structure.

Multiple industries use a range of diverse geospatial products and services, therefore, we should not view geospatial activity as taking place "within a single economic market". Take the information on aggregated user journeys as an example. It can be used by transport authorities to learn the patterns of changing demand on public transport, while private companies can use it to target their advertisements. Smartphone applications, like travel planning, video recording, photo taking, and health tracking, are embedded with geospatial data and other elements.

"The public needs more understanding of spatial data, and the same is true within the government. The government should formulate hard targets and guidelines for the internal use of geographic information."

2) The real value of geospatial data is difficult to assess.

In 2018, the U.K. Cabinet Office estimated that the private sector's use of geospatial data can unlock up to £11 billion (about HK$110 billion) of economic value each year, excluding the technology giants: Apple, Google, and Amazon.

In fact, geospatial data has been widely applied in many fields such as retail, logistics, dining, and travel, and forms a key part of commercial activity for a wide range of companies, thus, it is challenging to estimate its full value.

However, it is certain that the related industries have grown steadily: 55% of geospatial companies in the U.K. were established in the past 10 years. According to the data of two thirds of these companies, collected by the authorities, the number of employees has increased by about 45% annually, from 20,000 in 2009 to 115,000 in 2019.

3) The spill-over value of geospatial data cannot be underestimated.

The spill-over effect value of geospatial data refers to the value other than that captured by direct or indirect creators or users of the data. For example, the government's improvement in the management of the road network reduces carbon emissions, which in turn improves air quality, and slows down global warming, the entire society benefits as a whole, including people who do not use the road network.

Based on the above three characteristics, the report puts forward recommendations for the authorities. I think the one related to policy makers is particularly relevant for us.

Policymakers' myth

Even though geospatial data can produce huge economic and social benefits, the report points out that these data are often not fully utilised or can even be left unused. This may be due to a lack of knowledge in applying geospatial data by the policy makers, and therefore geospatial insights are not utilised in the decision-making process.

In Hong Kong's *2017 Policy Address*, opening government data was identified as one of the eight major directions to promote the development of innovation and technology. From 2019, the number of open datasets has been over 4,670, laying a solid foundation for a common spatial data infrastructure (CSDI), a data supermarket, to be officially launched in 2022.

Although opening up and sharing data with the public is seen as an important attribute for a smart city and a driving force of the new economy, do we get the expected results? What about the usage of this data by the public and the government? How much value has been created?

Wilson Wong, director of data science and policy studies at The Chinese University of Hong Kong, pointed out that many policymakers believe the myth that publicising data will automatically yield benefits and every constituent can make use of open data. However, the findings of a survey on Hong Kong people's views towards open data show that less than 40% of people have heard of "open data".

Civil servants' low awareness of open data

Apart from people's low awareness of open data, many civil servants also are not conversant with it. For example, an interactive map released by a government department used information from a private company instead of that from the government, such as the Lands Department's Hong Kong GeoData Store which provides map and location search application programming interface (API).

It seems that the information from private companies can sufficiently replace those from official sources. However, content from private companies is usually linked with advertisements, and the data is not as professional and precise as the government's.

For programme developers, the data from private companies lacks major analysis functions such as geographic data filtering and a key statistics display. Using this data gives the impression that the government is as short sighted as an amateur user.

The government should set hard targets internally

That is why the newly launched Geospatial Lab has a big role to play as one of its main tasks is to promote professional geographic information to the public.

The government, on the other hand, should strengthen training internally and consider setting clear, hard targets to formulate guidelines for using geographic information. For example, the Singaporean government requires all ministries to try artificial intelligence for policymaking in its bid to promote the application of advanced technologies.

The government should not continue its laissez-faire policy. Otherwise, it will be difficult to make the best use of our open data, which will be a major driving force of the new economy.

Summary

In the post-epidemic era, to fully embrace digital transformation, the Hong Kong government needs a high-level organisation to move forward in a concerted manner, from planning sustainable strategies with holistic thinking, to strengthening civil servants' awareness of spatial data. It is only by doing so that Hong Kong can take the smart city development to a higher level, enhancing its competitiveness in an all-round manner.

Best practice of Hong Kong's smart city applications

05

The applications by 9 organisations demonstrate Hong Kong's best practice in smart city transformation. They are: the Airport Authority Hong Kong, the Civil Engineering and Development Department, the Environmental Protection Department, the Food and Health Bureau, Hong Kong Air Cargo Terminals Limited, Hongkong Electric Company Ltd., Kadoorie Farm and Botanic Garden, the Lands Department and the Urban Renewal Authority.

(Organisations and government departments are arranged in alphabetical order)

Special thanks to the above 9 organisations and government departments for contributing articles and pictures.

5.1 Airport Authority Hong Kong

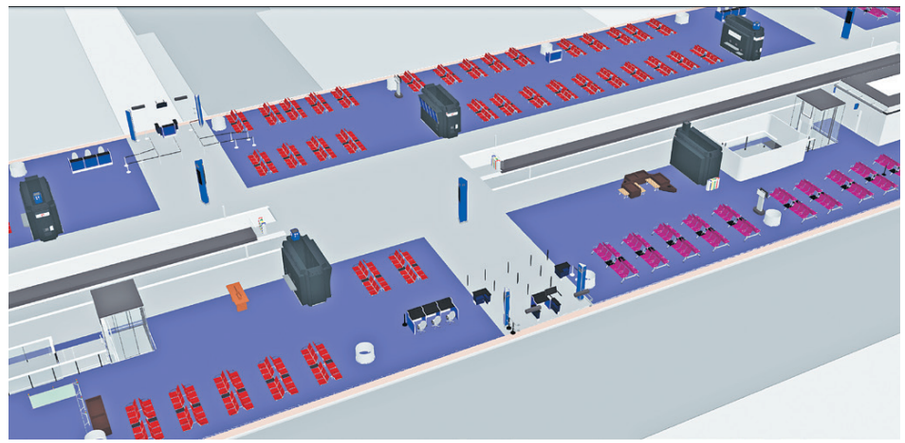
Mr Ricky W K Leung
Executive Director, Engineering & Technology, AA

Hong Kong International Airport (HKIA) has been one of the top leading aviation hubs in Asia Pacific. In 2018, the number of passengers was forecasted to increase from 70 million to over 100 million by 2030. To respond to this growth trend, the need to transform HKIA into a Smart Airport becomes more imminent, aiming for a higher operating efficiency and better passenger experience.

One of the supporting initiatives for this transformation is to create a Digital Twin for the airport. We define "Digital Twin" as a virtual model of HKIA, with the target to easily monitor and manage the airport environment as well as to track all the events centrally. Simulations and predictions without causing disruptions to the real environment are also key expectations for the outcome of this programme.

The Geographic Information System (GIS) is one of the key components of a Digital Twin. It serves as our single source of truthful data for systems. Starting at the beginning of the project in 2018, we first created our airport island outline by using combinations of both aerial and ground LiDAR scans, Computer Aided Design (CAD) drawings, and Building Information Modelling (BIMs). The physical airport infrastructure was then built by integrating GIS maps with BIMs and our asset management system. This allows us to retrieve asset information from GIS in a 2D/3D based virtual layout of the airport.

"GIS enables our teams to collaborate efficiently via maps and cartography."
- Mr Ricky W K Leung, Executive Director, Engineering & Technology, Airport Authority Hong Kong



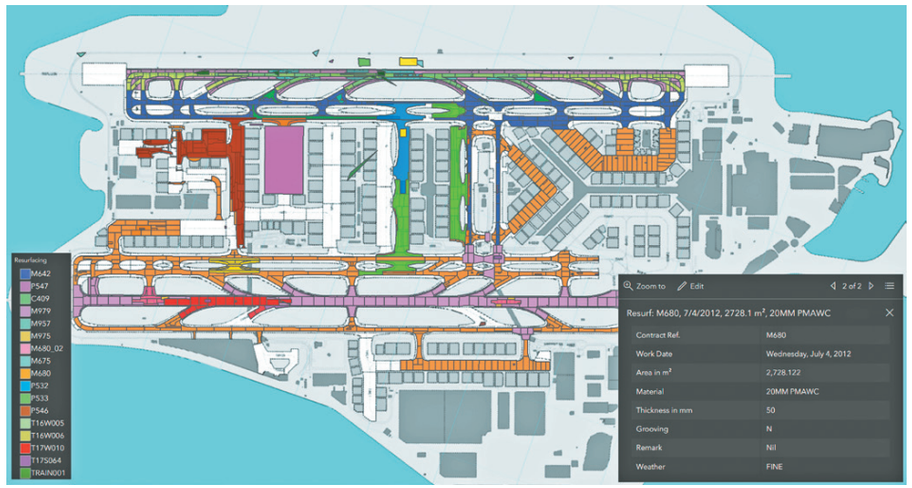
>> GIS with Airport Asset Management System Integration

Within 2 years, HKIA established a GIS platform and implemented a number of airport applications for operational needs. Other applications that require geo-referenced data will be considered for migration into GIS or linked to extracted GIS maps from the system. In 2021, the Internet of Things (IoT) data will be integrated into GIS for analysis to further improve our operations effectiveness and to enhance the passenger experience.

As GIS is our single source of true data for the HKIA Digital Twin, all geo-referenced facilities and assets data can now be easily managed and synchronised with connected systems. By integrating GIS with BIM and the Asset Management system, engineers can view status and fault reports via 3D models in GIS. Situations that require immediate attention can be significantly enhanced for decision making and for the handling of unforeseen disruptions at the airport. GIS also provides a holistic management and decision making platform. By building applications on GIS, operation and maintenance for an asset's full life cycle can be enhanced.

As an example, to ensure the airport pavements are properly maintained, a GIS application has been developed for engineers to see a holistic view of the whole airport pavement history and status; this allows better planning for future maintenance activities. Simulations and predictions in the GIS digital platform are also enabled at minimum cost and without causing disruptions to the real environment. For example, through the GIS Potable Water System application that provides the exactly georeferenced locations for pipes and nodes underground, we can now simulate the closing of valves to understand the effect of changes to water-flows. This enhances the overall process for pipework maintenance and minimises the risk of damage from human-errors.

Within 2021, we plan to integrate various IoT data into GIS and to build analytic applications to further improve our operations effectiveness. For example, a Storm Water Flooding application will be developed and launched in GIS. By using the IoT data related to flooding as a base to create analytics, simulations and forecasts, the results and insights can be displayed in GIS and it would enable better planning to control flooding.



>> GIS application – AirfieldPavement

5.2 Successful story of GIS application from GEO of Civil Engineering and Development Department

Ir Dr Raymond Cheung, JP
Head of Geotechnical Engineering Office, CEDD,
HKSAR Government

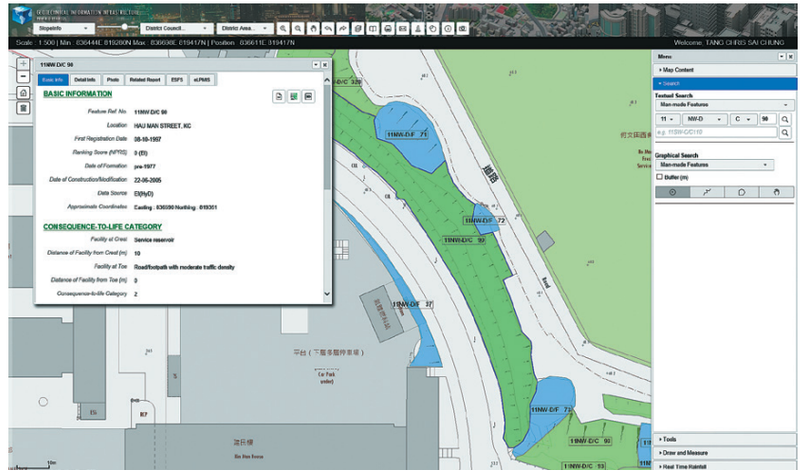
Hong Kong is a densely populated city with a small land area. The rapid economic expansion since the 1950s has been accompanied by many constructions on our hilly terrain. However, slope engineering practices were rudimentary in the early days and fatal landslides were not uncommon. The Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) was established in 1977. Since then, the GEO has implemented the Slope Safety System and the landslide risk has now been substantially reduced to a reasonably low level. A plethora of slope and geotechnical data is collected by the GEO in the process of quantifying and managing the landslide risk. A common attribute of these data is the spatial reference, by which geographic information system (GIS) is particularly suited to manage the data. Apart from this, the GEO engaged GIS to manage the marine fill and disposal areas for the reclamation of the Chek Lap Kok International Airport. Nowadays, GIS has been part and parcel of many services provided by the GEO.

"GIS is an essential tool for the Geotechnical Engineering Office in managing and analysing vast amount of geospatial slope and geotechnical data. This provides crucial support for discharging our duties of keeping slopes safe and protecting the lives and property."
- Ir Dr Raymond Cheung, JP, Head of Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government

In 1999, the GEO completed a project to comprehensively identify and systematically register sizable man-made slopes in Hong Kong into a catalogue, which now contains more than 60,000 in total. GIS has been used to manage the vast amount of slope data and for which the Slope Information System (SIS) was developed for disseminating them to government and public users. The SIS was a cutting-edge pioneer system amongst modern cities faced with similar landslide risks at that time. Besides the data management application, the GEO also utilises the GIS to undertake many engineering analyses. GIS is particularly suitable for determining spatial correlations and recognising unapparent patterns. The GEO uses GIS to establish the rainfall and landslide correlations that are essential to the operation of the Landslip Warning System in Hong Kong. The landslide debris mobility modeler is developed on the same GIS platform, in which physical and engineering principles are coded and integrated with the digital terrain model to identify the flow path of the debris.

In 2009, the GEO set up the Geotechnical Information Infrastructure (GInfo), which was an important milestone for expanding the applications of GIS. The infrastructure comprises enterprise-based GIS mapping and geodatabase servers, as well as an internet accessible network. Riding on the GInfo, many map-based applications and services can be realised. A centralised data repository is created in the enterprise geodatabase, which has more than 80 core datasets and exceeds 6 TB in size. The datasets include ortho-rectified aerial photos, slope data, ground investigation records, LiDAR, etc., which rely heavily on the enterprise geodatabase to efficiently serve the data to the users. The SIS was migrated to the GInfo as a web-based application with customised geoprocessing functions for quickly retrieving and analysing slope and geotechnical data. Currently, more than six hundred GEO colleagues and 2,000 engineering consultants and practitioners use the GInfo in their daily routine to retrieve geospatial data for slope engineering and development projects. The SIS also includes a public interface for them to retrieve slope data when planning for slope maintenance works. In 2020, some 46,000 hits in the public interface were logged.

The GInfo also enables the GEO to develop native GIS mobile apps that allow our geotechnical engineers to upload, in real-time, the observations made during field inspections. In recent years, the GEO has developed the "Smart Barrier" with Internet-of-Things (IoT) sensors and cameras installed. The data and images captured are integrated on the GIS mobile app "mGInfo", which nowadays includes all the important GEO systems. GEO colleagues could acquire the status of reported landslides, the rainfall situation, Landslip Warning and Smart Barrier, as well as the slope information in the SIS. This greatly enhances the GEO in managing landslide emergencies during inclement weather.

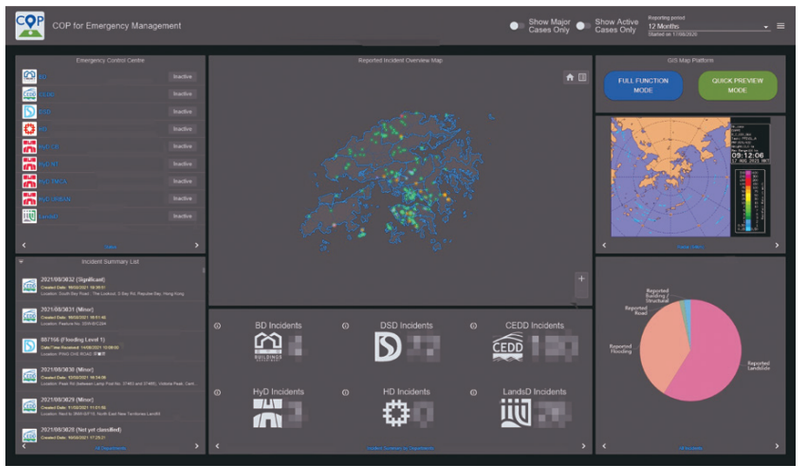


>> Geotechnical Information Infrastructure (GInfo)

In 2017, the GEO developed the Common Operational Picture (COP) that aims to improve the situational awareness of emergency incidents caused by natural hazards. The COP is essential to decision makers in conducting collaborative planning and coordinating strategic actions amongst different entities tasked with a broad range of natural disasters. When it was launched in 2020, the COP supported six government Works Departments in sharing, in real-time, emergency situations, including flooding, landslides, structural incidents and major road blockages. The COP is a GIS map based application deployed on the cloud platform to ensure its availability at all time. The advantages of the COP have been proven when Hong Kong was threatened by past typhoons. The government decided to further develop and incorporate more departments to partake in the COP, including reports of

fallen trees. The COP is an essential application that supports the operation of the government Emergency Monitoring and Support Centre.

It has been our strategy to build the GIS capability as one of our core corporate competences. GIS training is arranged for all our colleagues as an essential course. The GEO will continue nurturing a team of powerful GIS users and workforce, who enable us to develop GIS systems and applications, as well as taking full advantage of GIS's capability to enhance our services. In the coming years, it is our plan to pursue the latest GIS capabilities in slope and geotechnical engineering, such as 3D geological modelling, and the integration of GIS with Building Information Modelling (BIM) and location-based services.



>> Common Operational Picture (COP)

5.3 Environmental Compliance Division (ECD) of the Environmental Protection Department

Mr Wong Yiu-kwong, Ken
Former Assistant Director (Environmental Compliance), EPD, HKSAR Government

The Environmental Compliance Division (ECD) of the Environmental Protection Department (EPD) handles over 22,000 pollution complaints and 60,000 investigation cases each year as well as managing over one million such records in our database system which was developed more than 12 years ago. With a view to enhance operational efficiency, the ECD has been applying GIS-based technologies since 2018 to replace paper-based workflows, including the use of mobile devices for site inspection, streamlining back-office inspection reporting and logging, providing instant case retrieval and referral, and supporting big-data analyses to provide management information for better strategic and operational enforcement planning.

The development and implementation of IT applications is being championed by the **ECD Smart Technology Task Force** which taps into the ideas and wishes of colleagues in all ECD Groups, examines existing systems, defines goals and sources the right technology and hardware, shares successes,

> *"GIS technologies give you the power to capture, visualise and interact with information, presenting it with geographic precision on a map in real time with your displays help you make more informed decisions. Applying the power of GIS to the Environmental Compliance Division of the Hong Kong Environmental Protection Department has greatly enhanced our operational efficiency in a surprising degree in terms of information sharing, record management, manpower saving, improved communication during operations, better decision making and strategic planning. Do give it a go, and you will also be amazed how GIS can do the same for your organisation."*
>
> *- Mr Wong Yiu-kwong, Ken, Former Assistant Director (Environmental Compliance), Environmental Protection Department, HKSAR Government*

organises user training and seeks feedback for improvement. Together, we have explored and adjusted, but the following successful examples will keep us venturing into more GIS applications in order to better serve the community of Hong Kong.

In response to the widespread illegal dumping of renovation waste and the increasing number of complaints, the ECD has developed a "**Spotter App**" in early 2020 to enable field inspectors to use their hand-held devices such as mobile phones to report abandoned renovation waste spotted during regular patrols and inspections. The **Spotter App** is developed on a GIS platform which supports the real-time transmission of geographical locations and instant photos. This real-time reporting feature has tremendously reduced the processing time for responding to complainants as well as referring cases to the relevant departments for clearance by more than 40% for over 90% of the cases.

The ECD has also extended the use of GIS technologies to other enforcement and surveillance duties which were beyond imagination in past years. These applications include drone deployment, providing live video streaming on GIS maps, for surveillance, compliance monitoring, and emergency responses to pollution incidents. The GIS platform also enables the sharing of essential environmental information such as drainage plans, ecologically sensitive areas, potential polluting sources, past records, etc. through mobile devices with exact geographic references to support frontline inspectors in making informed decisions during field enforcement operations, thereby greatly enhancing the department's effectiveness in tracking down pollution sources, containing environmental damage and bringing offenders to justice.

Aside from enforcement duties, the ECD has also applied GIS technology to other projects during the Covid-19 pandemic. With a slightly modified version of the **Spotter App**, the ECD provided support to the government's Anti-epidemic Subsidy Scheme for the Laundry Trade in reaching out to the laundry shops over the territory to promulgate the Scheme, facilitate applications, and gather basic shop information to expedite approvals, thus providing timely financial relief to the Trade hard-hit by the pandemic. In addition, the **Spotter App** has helped the EPD audit teams to check on the provisions of anti-epidemic measures in the public transport sectors, including

MTRC trains, franchised buses, mini-buses, trams and ferries, in order to safe-guard passengers from virus infection.

Taking advantage of the multi-layering information capturing and visualisation features of the GIS platform, the ECD has also been performing a pivotal role in the sewage surveillance project that supports the government's fight against the 4th wave of Covid-19 outbreak since November 2020. The GIS dashboard monitors the situation of the spread of the Covid-19 virus by tracking the testing results of sewage taken from manholes of street blocks and buildings, providing crucial scientific basis amongst other considerations for identifying buildings and places for compulsory testing or "restriction-testing declaration" operations. This is made possible by providing a shared GIS platform for the cross-disciplinary project team of the University of Hong Kong and colleagues of government departments, including the EPD and the Drainage Services Department with the real-time visualisation of updated spatial distributions of Covid-19 confirmed cases, concerned buildings, or places where the confirmed cases are reported, the related public sewerage networks, population data, etc. Thus facilitating the project team in making timely decisions in planning the sewage sampling and testing schedules that aim at pinning down asymptomatic patients ahead of another potential outbreak.

>> The EPD has set up the Smart Control and Command Centre which operates on a GIS platform and integrates live video feeds, case records, inspection reports, spatial analytic information, etc. on GIS maps for enforcement planning and command during operations.

>> "Pollution Tracking Spotter App" with GIS positioning and real-time transmission is operated on hand-held mobile devices for pollution control enforcement duties in EPD.

5.4 Food and Health Bureau : Fighting Covid-19 with GIS

Mr Thomas Chan, JP
Permanent Secretary for Food & Health (Health), FHB,
HKSAR Government

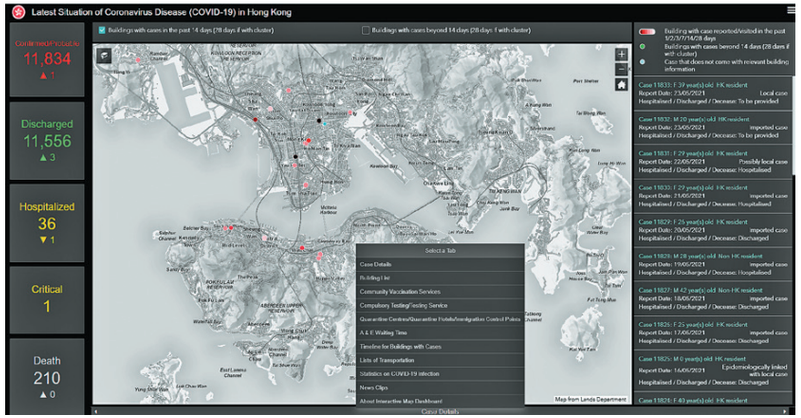
Hong Kong has been extensively affected by the Coronavirus Disease-2019 (Covid-19) since early 2020. At the time of writing (mid-May 2021), the Hong Kong Special Administrative Region (HKSAR) has experienced four waves of epidemic and the local situation has remained mostly stable. The fight against the Covid-19 epidemic has been guided by science and evidence, and the application of technology has played an indispensable facilitating role. Amongst others, the Food and Health Bureau (FHB), with the support of the Lands Department (LandsD), the Information and Technology Bureau, the Development Bureau, the Department of Health and volunteers from the Smart City Consortium, the Hospital Authority, etc., have effectively utilised the geographic information system (GIS) to develop an interactive map dashboard, the Case Investigation and Management Portal, as well as the Geospatial Information Portal, to name a few, to support the planning and implementation of anti-epidemic measures.

Keeping the public informed of the latest situation and key information

Effective dissemination of Covid-19 information to the public is a crucial measure with a view to better informing the community of the risk to which

> *"The fight against the Covid-19 epidemic has been guided by science and evidence, and the application of innovation and technology has played an indispensable facilitating role. The robust application of GIS allows us to visualise and analyse vast amount of data and attributes of Covid-19 cases. This supports us in making strategic and targeted decisions promptly and precisely, in order to cut the viral transmission chain and safeguard public health."*
> *- Mr Thomas Chan, JP, Permanent Secretary for Food & Health (Health), Food & Health Bureau, HKSAR Government*

they may be exposed, and staying away from possible sources of infection. In February 2020, the early stages of the epidemic, the interactive map dashboard had been developed with GIS within a very short time. It makes use of government open data to enable the public to more conveniently learn about the latest developments of the epidemic at a glance on their computers and smartphones. Through an interactive and user-friendly map layout, it presents statistics on Covid-19 infection, information on buildings where confirmed cases have appeared, places where confirmed patients have visited, as well as information on the community testing services, the quarantine centres, and community vaccination services, etc (Figure 1). As of mid-May 2021, the desktop and mobile versions of the Dashboard have attracted more than 52 million view counts since its first launch. Datasets of



>> Figure 1: An interactive map dashboard on Covid-19 enables the public to learn about the latest developments of the epidemic at a glance.

the Dashboard are also available to the public through data.gov.hk from the Office of the Government Chief Information Officer.

Guiding policy implementation

Provision of testing services

To achieve "early identification, early isolation and early treatment" and cut the transmission chain as early as possible, the government has introduced compulsory testing for those with a high-risk and high-exposure (such as taxi drivers and those working in elderly homes), testing for targeted groups (such as frontline staff, foreign domestic helpers, etc.) and offered free testing to the public on a voluntary basis. To meet the considerable demand for testing, a total of 21 Community Testing Centres have been set up to provide over 38,000 tests per day. To ensure these Testing Centres are easily accessible, location-allocation analysis using census and 3D pedestrian network data was carried out to determine the optimal locations for setting up the community testing centres and specimen collection points to serve the most people within a walkable distance.

Contact tracing

Strengthening the tracing of contacts from a confirmed case is crucial to help cut the viral transmission chain and prevent the further spread of the virus in the community more efficiently and effectively. A couple of internal information portals have been developed to enhance contact tracing. The Case Handling and Information Sharing Portal links information systems of various relevant departments and agencies to centrally and electronically collect the information needed for contact tracing, so as to streamline the procedures for information collection, input and sharing, which was previously mainly conducted manually. Geocoding services based on GIS technology has been enhanced to improve the accuracy of inputting addresses and the whereabouts of confirmed cases. This helps improve the efficiency and effectiveness in tracing contacts of confirmed cases, conducting testing, and arranging quarantine or medical surveillance for such contacts.

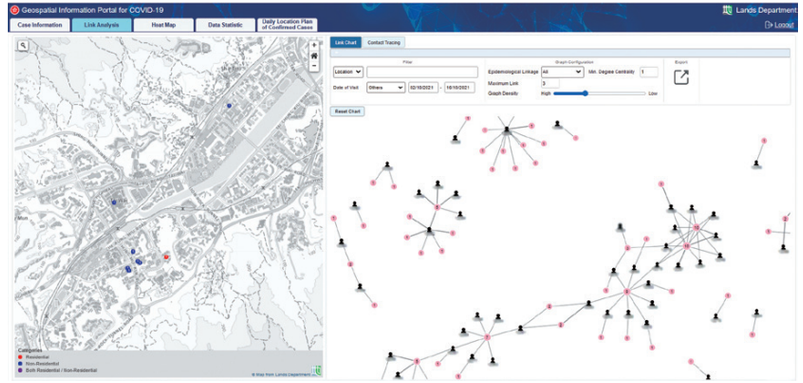
The Geospatial Information Portal (GIP), on the other hand, not only shows the relationship between each location and all its related confirmed cases, but also supports investigators to collate the epidemiological relationship between the index case and contacts, such as incubation period and

communicable period, with georeferenced common meeting points through the linkage of their exposure / movement to study individual behaviour and activities (Figure 2). The visualisation of geographical information from common contacts of confirmed cases of Covid-19 helps evaluate the relationship of geolocations that can in turn help predict the spread of the Covid-19 virus.

Supporting policy analysis

The web-based GIP is an all-in-one specialised platform which maintains the most up-to-date epidemic information and operational data, so as to facilitate the FHB and other relevant government departments to grasp the latest situation of Covid-19 in Hong Kong and to plan for appropriate anti-epidemic responses. Its development has been supported by the Survey and Mapping Office of the LandsD. GIP sets out information including preliminary positive cases, case details, the history of intervention on individual location (such as whether compulsory testing had been imposed in the past), catchment, and the results of sewage surveillance, etc. GIP's heat-map analysis also helps visualise where clusters of Covid-19 confirmed cases occur. The GIP also contains enhancements which provide dedicated software tools to facilitate specialists in performing spatial analyses on the spread of the confirmed cases so as to identify high risk areas. The majority of operations in restriction-cum-testing (or commonly-known as seal-off), enforcement, evacuation, etc. are planned with the aid of the GIP.

In summary, GIS has been well proven as a powerful and promising decision-making tool contributing to Hong Kong's internationally recognised achievements in combating Covid-19. While we are confident that Hong Kong can get through the epidemic soon, we look forward to further practical applications of GIS in other areas of the healthcare sector in future.



>> Figure 2: The Geospatial Information Portal not only shows the relationship between each location and all its related confirmed cases, but also supports investigators to collate the epidemiological relationship between the index case and contacts.

5.5 Hong Kong Air Cargo Terminals Limited (Hactl)

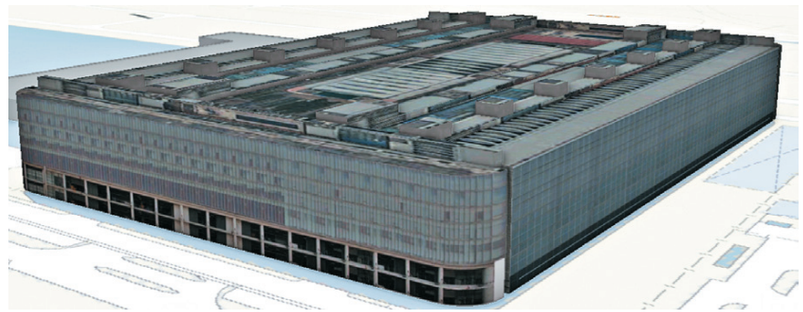
Ms Cindy Ng
Executive Director, Information Services, Hactl

Hong Kong Air Cargo Terminals Limited (Hactl) is one of the world's leading air cargo terminals with world-class facilities, highly efficient operations, and innovative technology. In terms of cargo traffic, the Hong Kong International Airport has been the busiest airport for ten consecutive years since 2010 (data provided by Airports Council International).

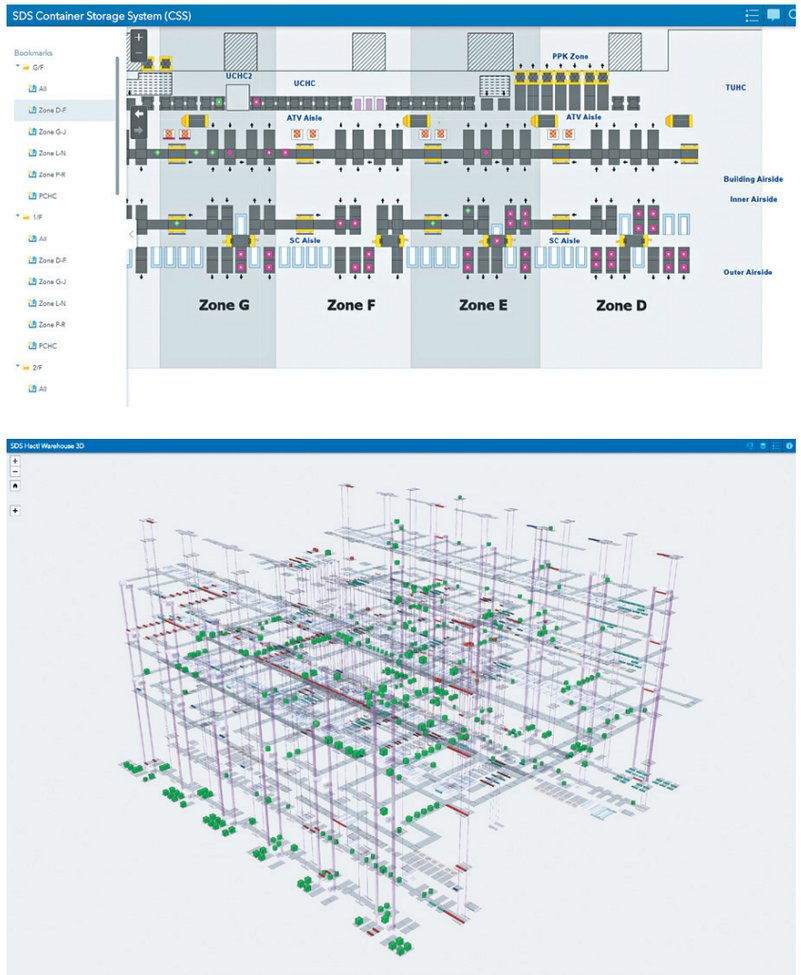
Operating since 1976, Hactl is established to support the import, export and transhipment of air cargos with 24/7 round the clock operation in Hong Kong, contributing to the growth of the economy in Hong Kong. Our fully automated multi-floor Container Storage System (CSS) provides more than 3,500 storage positions. In addition, a Box Storage System (BSS) that provides 10,000 computer-controlled storage positions for general import, export and transhipment cargo.

Since the efficient operation of the air cargo terminals is crucial to Hong Kong, Hactl pays extra effort in adopting the most innovative technology and developing the best practices in the industry. As early as 2005, Hactl started exploring a better visualisation platform for operation personnel to monitor the locations and operations of the air cargos in the automatic cargo

"We work with GIS experts at Esri China (HK) to develop specialised programmes, services and solutions that help the logistics industry transform the way air cargos are moved around the globe with higher efficiencies, increased customer service levels, and better on-time delivery performance."
- Ms Cindy Ng, Executive Director, Information Services, Hong Kong Air Cargo Terminals Limited



>> A 3D mesh model has been created for SuperTerminal 1



>> GIS powers the schematic display system (SDS) in 2D and 3D perspectives

handling system, and we eventually found that Geographic Information Systems (GIS) could offer the best solutions.

The dynamic nature of cargo transfer often leads to cargo traffic bottlenecks and increased waiting times. This can lead to late dispatch, or even flight delay. The GIS technology helps us centralise our data and, in the process, alerts can be set up which our personnel can access to see accurate and timely information and then clear any issues in the bottlenecks. We can therefore effectively manage the coordination of transfers and dispatch throughout our cargo handling system.

Leveraging the expertise of Hactl's Information Services (IS) team, we developed and implemented our own Logistics Control Systems (LCS), consisting of LCS-CSS and LCS-BSS for air cargo handling. With our in-house Schematic Display System, GIS has been applied to provide the system with the capability to track and visualise equipment locations, resource distribution, and it allows load performance diversion to alternative routes for the cargos in SuperTerminal 1. With the successful adoption of GIS applications, we were pleased to win the Special Achievement in GIS Award in 2007.

In our service, being on time and meeting customer expectation is everything. Dispatchers need to prepare for any threat to delivery operations — from contamination to adverse weather conditions. Our IT teams work with GIS experts at Esri China (HK) when we develop specialised programmes, services and solutions that help the logistics industry transform the way air cargos are moved around the globe, yielding higher efficiencies, increased customer service levels, and better on-time delivery performance.

In recent years, we have upgraded the LCS to LCS-Plus, in which real-time visualisation and spatial analytics with data feeds from sensors, IoT devices and cameras have become more sophisticated. GIS has played an important role in providing us with location intelligence and we have gained situational awareness from the streaming data whenever we are tracking moving cargos. We can also access imagery and remote-sensing data feeds to monitor delivery status on a smart map display.

To further make good use of GIS technology, we are planning for more upgrades to our system to visualise a three-dimensional (3D) display that can be viewed floor by floor from different angles. Having both 2D and 3D will give us more flexibility to work. The same data can be examined from a 2D and 3D perspective, which allows for new insights into that data. Using GIS, we will keep pioneering a great number of innovative solutions, continue to create a better customer experience and raise the service standard to a new level.

5.6 Hongkong Electric

Mr Francis C.Y. Cheng
Operations Director, HKE

The Geographic Information System (GIS) is a very important tool in HK Electric for managing the assets of its transmission and distribution network. Before the 1980's, substations, cables, and the associated cable joints were drawn on paper maps according to their installed locations.

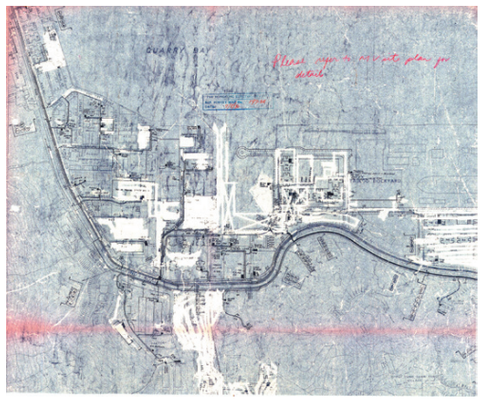
HK Electric started to use its "Mapping Computer System" in 1981 by converting the data on paper to computer records through manual digitisation to show the information on base maps. Schematic diagrams of cable circuits were included and information attributes were input in the form of "tags" and linked to the records created for asset management.

By 1989, all the information was in digital format but the mapping computer system had to be operated by well-trained computer operators while printed paper maps were used for daily site activities. A MapView solution by displaying information on desktop computers was launched in 2002 to improve work efficiency.

HK Electric also established unique IDs and attributes for each facility in the mapping computer system for linking the supply sources with the customers to show network connectivity, and incorporated network planning information for various functions such as outage scheduling. The mapping computer

"HK Electric's GIS is indispensable for managing our electricity network. By continually upgrading our system with market-available technologies, our capability of planning, expansion, modification, replacement and upgrading of our network assets have been enhanced."
- Mr Francis C.Y. Cheng, Operations Director, Hongkong Electric

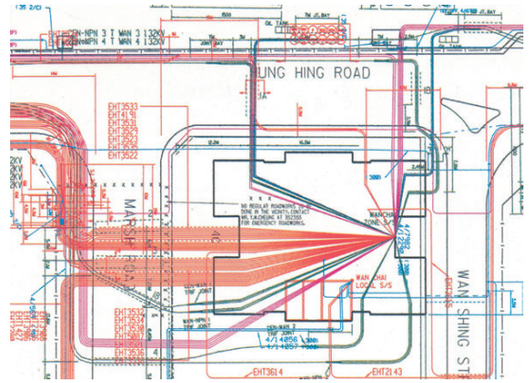
>> Drawing Cabinet used before 2000



>> Old mapping record

system was subsequently renamed as "Geographical Information System" as it had transformed from a simple data and spatial location collection system into a highly sophisticated asset management framework.

>> Photo of a computer room in 1991 to 2000



>> Map display in GIS

At present, HK Electric is still continuing to develop its GIS by introducing new elements such as 3D information for spatial analysis, the use of a web-based system to enhance mobile access and incorporate communication facilities. A new GIS system of the next era is under development and is scheduled for launch in 2023.

5.7 Kadoorie Farm and Botanic Garden

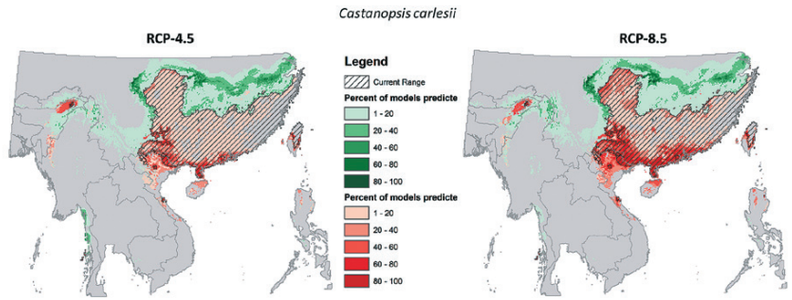
Dr Cheuk Mang Lung
Senior GIS Specialist, KFBG

When I was working on my final-year project as a college student, I was fascinated by GIS. It broadened my vision and helped me to analyse the spatial relationship between land use and dust-fall in my hometown. Since then, I decided to pursue further studies in GIS for environmental conservation. Fortunately, I was able to join the Kadoorie Farm and Botanic Garden (KFBG) and put my knowledge into practice.

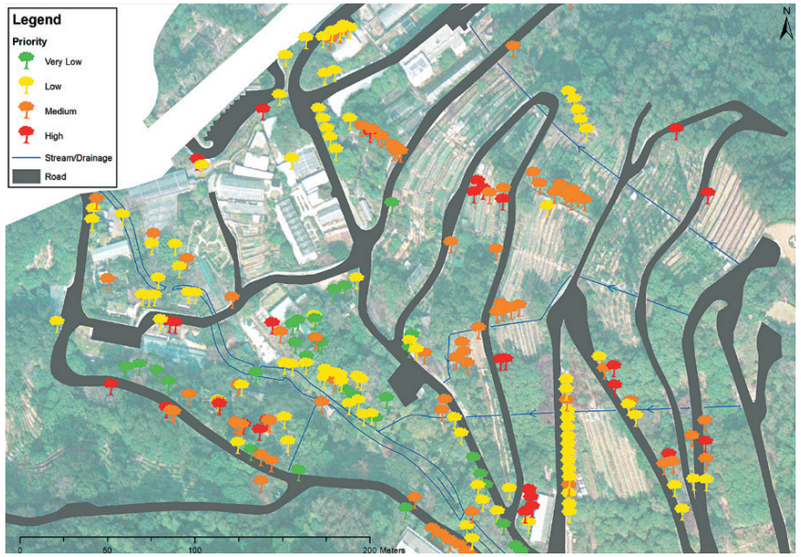
Maps enable us to communicate with workers and contractors more efficiently. On a daily basis, we store the location of every roadside tree in a GIS database for tree management. Geometric parameters of facilities can be calculated and mapped for communicating with workers and contractors. Besides, spatial analysis of topography allows better decisions to be made on forest conservation and in emergencies. For example, we mark the location of Aquilaria sinensis and determine the protected area and route of patrol. We examine the growth of tree seedlings and topographic factors such as aspect, slope, and convexity to understand suitable habitats for native species.

GIS also supports additional research dimensions such as analysing the relationship between plant distance and genetic diversity, modelling the influence of climate change on tree distribution in south China and examining the relationship between past forest cover and current species diversity. To summarise, GIS benefits our organisation by providing a way for better communication, decision making, and research opportunities.

> *"Knowledge is embedded in nature. GIS enable us to explore the knowledge and make a better decision by visualising, summarising, and analysing the spatial relationships of various environmental settings."*
> *- Dr Cheuk Mang Lung, Senior GIS Specialist, Kadoorie Farm and Botanic Garden*



>> Species distribution modelling of Castanopsis carlesii under two climate change scenarios (RCP-4.5 & RCP-8.5). The red area represents losing habitat suitability while the green area represents gaining.



>> Mapping roadside trees for better tree management in the garden

5.8 The Lands Department: The role of geospatial information in the smart city development of Hong Kong

Mr Chan Siu-bun, Ben
Deputy Director/Survey & Mapping, LandsD,
HKSAR Government

Mr Fan Ko-kwan, Ben
Land Surveyor/3D Mapping, LandsD,
HKSAR Government

In the report *Future Trends in Geospatial Information Management: The Five to Ten Year Vision, Third Edition,* the United Nations Committee of Experts on Global Geospatial Information Management highlighted how geospatial information and technology would underpin national governments over the next five to ten years. It further documents the increasing role that geospatial information will play as part of the 2030 Agenda for Sustainable Development.

Technology in the 21st century plays a prime role in disrupting the geospatial industry. The latest evolution of technology has impacted the design and function of modern land surveying and mapping techniques in a massive way. The traditional two-dimensional paper maps that have been widely

> *"The traditional two-dimensional paper maps that have been widely used in the past century have evolved into a three-dimensional digital model of the real world. We are now going beyond that to encompass not only the geometric description of the real world, which is effectively a digital map, but to provide the maturity element to develop Digital Twin through transforming the real world into a complete digital model."*
> *- Mr Chan Siu-bun, Ben, Deputy Director/Survey & Mapping; Mr Fan Ko-kwan, Ben, Land Surveyor/3D Mapping, Lands Department, HKSAR Government*

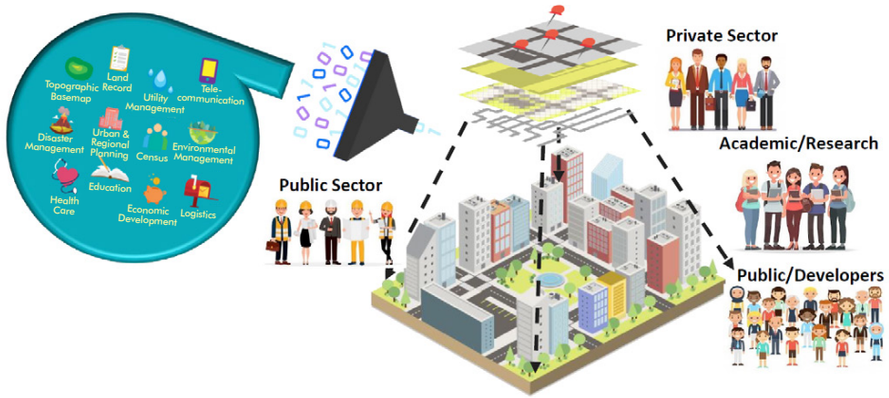
used in the past century have evolved into a three-dimensional digital model of the real world. We are now going beyond that to encompass not only the geometric description of the real world, which is effectively a digital map, but to provide the maturity element and develop a Digital Twin through the transformation of the real world into a complete digital model.

In 2017, the *Smart City Blueprint for Hong Kong* set out the overall framework and strategy to use innovation and technology to address urban challenges, enhance Hong Kong's attractiveness to global businesses and talent, and inspire city innovation and sustainable economic development. The *Smart City Blueprint for Hong Kong* included the adoption of Building Information Modelling (BIM), the development of Common Spatial Data Infrastructure (CSDI) and the development of a 3D Digital Map.

The 3D Digital Map shall be one of the prime elements for developing the Smart City and a Digital Hong Kong. The 3D Digital Map, which forms a major building block of CSDI, facilitates the sharing and opening of government geospatial data. The new form of 3D Digital Map is not only a transformation of the existing and traditional 2D digital map with additional enrichment, but also a full-fledged 3d digital surface model with an accurate portrayal of physical structures using various modern survey and mapping technologies. The 3D Digital Map will also cover the accessible interior space of buildings and structures. The attribute-based spatial objects in the 3D Digital Map, including floor-level and unit-level geometries and attributes, will be the core components in the next generation of geospatial applications.

The CSDI for Hong Kong aims to increase the interoperability, accessibility, and usability of spatial data among all members of the community. It also facilitates the business sector and startups to make use of spatial data in exploring innovative applications and in creating value-adding spatial products for society.

In Hong Kong, the number of smartphone users in 2019 was estimated to be 6.5 million. It is predicted that about 93% of the population in Hong Kong will be smartphone users by 2025. Smartphones combining mobile internet access, an embedded digital map, and a positioning function have led to the booming of location-based applications and services, and will become essential parts of people's daily lives. Taking advantage of this growing



>> The Common Spatial Data Infrastructure (CSDI) platform supports interoperability, accessibility, and the usability of spatial data among all members of the community.

volume of smartphone users, geospatial information for location-based applications and services has become a game-changer for government and society.

BIM is the process of generating and managing building data during its design, and construction, and during the building or assets life cycle. BIM provides rich spatial and semantic contents to facilitate management and coordination throughout the construction life cycle. At the same time, geospatial modelling incorporates broader data capturing to understand our place from a territory-wide aspect better. These two technologies are necessary to streamline and enhance the entire Digital Engineering & Asset Management life cycle and further facilitate mapping to develop the 3D Digital Map.

Opening up digital map products, including the Map Application Programming Interface (Map API) services, enables the public, academia, and businesses to use spatial data in research and application development. In December 2020, three Map API services, including Topographic Map API, Imagery Map API, and Map Label API, were made available to the public free of charge on the Public Sector Information Portal (data.gov.hk) and the Hong Kong GeoData Store (geodata.gov.hk). In April 2021, the Lands Department of the government of the Hong Kong Special Administrative Region announced opening up digital map products free of charge. Products including Digital Topographic Map, Digital Land Boundary Map, Geo-Reference Database, Digital Orthophoto, Digital Aerial Photo (300 dpi resolution), GeoCommunity Database and 3D Spatial Data were released for free download on Hong Kong Map Service 2.0 (hkmapservice.gov.hk). The availability of free digital map data will facilitate the development of a digital economy, realising the visions of the *Smart City Blueprint for Hong Kong 2.0* and bringing benefits to society as a whole.

The successful development of the Smart City and Digital Hong Kong requires all stakeholders' support so that synergies can be created between government, industry, academia, researchers, and the public. The geospatial industry and professionals should seize this golden opportunity to play significant roles and contribute to the development of the Smart City and Digital Hong Kong.

>> The Lands Department of the government of the Hong Kong Special Administrative Region announced opening up digital map products free of charge starting from April 2021.

5.9 Urban Renewal Authority: A Journey of Thousand Miles Begins with a Single Step

（千里之行 始於足下）

Ir Wai Chi Sing, GBS, JP, FHKEng
Managing Director, URA

When I was Chief Engineer leading the Research and Development Unit of the Highways Department in 1997, I was inspired by a young lady, Ms Winnie Tang, being the then CEO of Esri (Hong Kong). As a layman in GIS, I was the first engineer from the Hong Kong government flying 12,000km to San Diego to attend the Esri User Conference, which has evolved to become the largest software conference event in the world nowadays.

It was a valuable and eye-opening experience for me. I witnessed innovative professionals in virtually any industry applying GIS technology to analyse complex spatial issues in different business areas, for example in supply chain management, mapping risk levels in the insurance industry, urban planning in organising land uses, and the placement of facilities for health organisations in analysing spatial distribution of infective diseases.

As a takeaway from the Conference, I saw the potential to apply the technology to the asset management of the Highways Department. I ventured

> *A Journey of Thousand Miles Begins with a Single Step (千里之行 始於足下). As GIS technology is inherently suitable for urban planning and renewal, I have motivated my team to develop a GIS-based Urban Renewal Information System (URIS). With technical support from a competent ESRI team based in Hong Kong, I personally chaired a steering committee to drive development of URIS applications covering various functions in URA, while investing substantially in training programmes on big data and location intelligence to groom data analysis and GIS talents within URA.*
>
> *- Ir Wai Chi Sing, GBS, JP, FHKEng, Managing Director, Urban Renewal Authority*

to set up the first-ever GIS-based Road Data Management and Mapping System in Hong Kong, for more effective management of road inspection and condition data, including those collected by mobile devices, road inventories and maintenance works, utility excavations, etc. Since its launch in the early 2000s, the System has been progressively upgraded into the second generation, featuring higher system reliability, user-friendliness, and data analysis capabilities. The Department is in the process of revamping the System further to enable 3D GIS functions for 3D asset management, and to integrate BIM data into grade-separated highway infrastructure, with a view to achieving productivity gains through resource optimisation of maintenance works.

>> 3D Freezing Survey/ Social Impact Assessment Tools

After over 30 years of services in government, I assumed the position of the Managing Director of the Urban Renewal Authority (URA) in 2016. Soon after taking up the top job, I saw the need to re-invent the organisation with greater emphasis on smart governance, and was convinced to embark on a journey to transform the URA into a data-driven organisation with an IT-savvy workforce, for sustainable organisational development and higher effectiveness in urban renewal.

A journey of thousand miles begins with a single step. As GIS technology is inherently suitable for urban planning and renewal, I have motivated my team to develop a GIS-based Urban Renewal Information System (URIS). With technical support from a competent ESRI team based in Hong Kong, I personally chaired a steering committee to drive the development of URIS

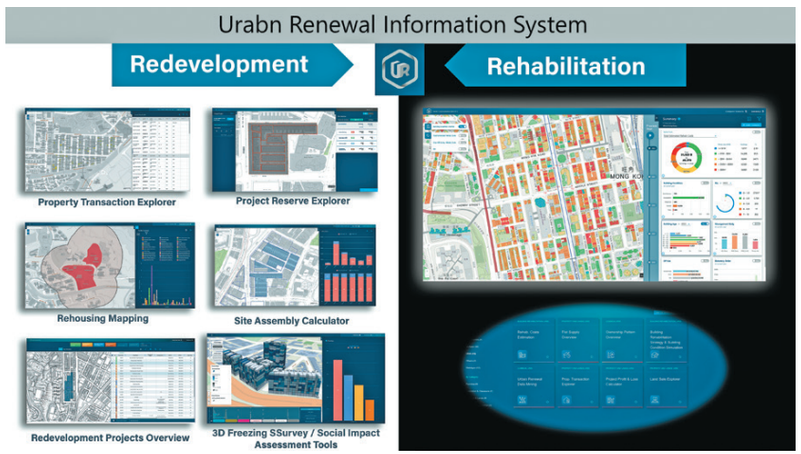
applications covering various functions in URA, while investing substantially in training programmes on big data and location intelligence to groom data analysis and GIS talents within the URA.

The system development efforts over the past years have borne fruit. To date, about 20 applications have been successfully developed through the joint efforts of ESRI and URA's in-house experts, resulting in cost savings, higher efficiency, and smarter decision-making and strategising in various functional areas including project selection, planning & design, financial assessment, property valuation and acquisition, rehousing, and building rehabilitation.

I dispelled the myth that GIS tools are exclusively for computer scientists and IT experts. On the contrary, I promoted the widespread use of URIS within URA, and challenged all division heads to avail themselves of the URIS platform to enhance their divisional operations, including those of supporting divisions. To strengthen corporate governance, the Human Resources Division has recently collaborated with the Planning & Design Division to develop an URIS application capable of detecting potential conflicts of interests and issuing timely alerts to the management.

Most recently, URA has broken new ground in creating a 3D indoor map to facilitate real-time progress tracking of freezing surveys required for newly commenced redevelopment projects, on a unit-by-unit basis. Similar applications are being deployed to instantly capture household data and aspirations collected under social impact assessments and project engagement exercises. Meanwhile, we are exploring how to capitalise on high-resolution 3D indoor maps recording details of interior and exterior buildings, down to common area and unit level, to guide the formulation of urban renewal strategies and action plans as required.

There remains unlimited potential to develop more powerful GIS tools and apply them to improve the built environment of Hong Kong and other developed cities, as by definition urban renewal is a never-ending exercise. Opportunities for improvement abound and will only be limited by the availability of research and development resources, and the boundaries of human imagination.



>> Urban Renewal Information System

Summary

The successful cases from these 9 organisations, covering transportation and logistics, environmental hygiene, public utilities, and the improvement of urban living spaces, demonstrate the determination of Hong Kong's public and private organisations in using innovative technologies, such as GIS, to improve efficiency and people's quality of life.

25 years footprint of Esri China (Hong Kong)

Caring for employees

We regard employees as an important asset of the company, the awards over the years are testimony of the company's belief in caring for employees.

2003

Awarded 18 Years Plus Caring Company Logo as a recognition of the company's continued efforts paid in corporate social responsibility programmes since 2003

2011

Commended as a Distinguished Family-Friendly Employer by the Family Council

2014

Recognised as one of the 500 Manpower Developers with outstanding achievements in manpower training and development under the ERB Manpower Developer Award Scheme organised by the Employees Retraining Board

Interacting with customers

Since its establishment 25 years ago, we have held several user conferences and open days in Hong Kong and Macau, attended by more than 10,000 visitors. In addition to exchanging new technological information with our clients, the events also shoulder the task of inheritance.

1998-2019

For more than two decades, it has become the company's tradition to organise tours for clients to attend the Esri User Conference in the United States each year. The picture was taken in 2019, staff members of Esri China (Hong Kong) with Jack Dangermond (third from left), Esri President and Co-founder.

1998

Kwai Fong office held the first Open House (15 September 1998)

The first Esri China (Hong Kong) User Conference

2003

Esri moved to Cyberport at the time of the SARS epidemic, an Open House was held in the 20,000 sq ft new office, crowded with customers and a steady stream of visitors (15 May 2003)

2004

Held my new book signing event for the first time at the Esri User Conference in San Diego, United States, a great chance for me to interact with clients from all over the world

2006

Held the first Esri Asia Pacific User Conference in Hong Kong

2010

During the 3rd Esri China (Hong Kong) User Conference, secondary school students participated in demonstrations and shared their user experiences

2015

The 10th Esri Asia Pacific User Conference was held in Hong Kong

2017

Successfully held the 4th Esri China (Hong Kong) User Conference with the team's joint effort and years of preparation, it was the finale for the celebration of the 20th anniversary of the company

Nurturing talent

In the development of the smart city, citizens need to have a heightened awareness of environmental conservation, a better understanding of smart city development, and more sophisticated problem solving skills. Therefore, for many years, I have been working hard to help young people equip themselves to meet future challenges.

2016-2021

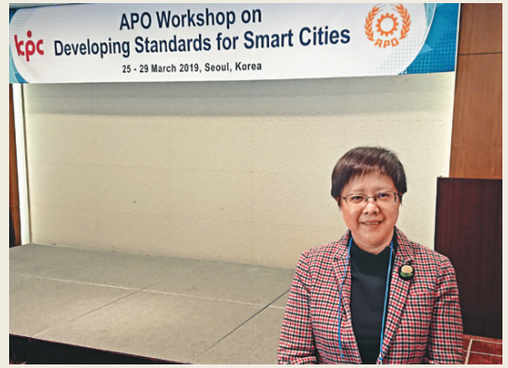
Launched Map in Learning Program that provides free digital learning materials to help students develop their diversified potentials. By the end of 2021, more than 220 schools have participated in the program and over 1,700 teachers and students have been trained.

2016-2018

Esri has supported the Inter-school Cross-Curricular Project Competition on Climate Change Prize-giving Ceremony 2016/17, and Smart City Project Programme 2017/18 organised by the Education Bureau for two consecutive years, encouraging all primary and secondary school students to use GIS to explore innovative solutions, and work together to build a smart city!

2017-2021

The Esri Young Scholars Award allows undergraduate and graduate students to analyse their chosen topics with GIS, the champion could receive a sponsorship to attend the Esri User Conference in the United States. The picture shows the 2018 winner Choy Tsz-hin (far left), myself and winners from other countries at the Conference.



2019

At the Asian Productivity Organization (APO) Workshop on Developing Standards for Smart Cities held in South Korea, I served as a trainer and delivered lectures on the smart city for government representatives and scholars from 19 member countries

2020

I was awarded Lingnan University's Honorary Fellowship. I am grateful for the recognition of my many years of hard work, including promoting smart city development, nurturing youngsters and startups, and promoting the use of advanced technology to enhance Hong Kong's competitiveness.

Caring for our community

Information technology has become a crucial part of daily life. For many years, I have been promoting social inclusion, driving all walks of life to bridge the digital divide.

2004-2016

Participated in the Cyber Run for Rehab that promotes disability inclusion

2012 and 2019

Further to the assistance offered in 2012, once again I helped the Hong Kong Society for Rehabilitation in establishing the Hong Kong Access Guide to provide accessibility information of barrier-free facilities in Hong Kong

2017

Held activities like Tech for Senior to facilitate the elderly embracing technology

2020

Partnered with Smart City Consortium expert volunteers and the government to develop the Latest Situation of Coronavirus Disease (COVID-19) in Hong Kong, an interactive map dashboard at the early stage of the pandemic

Mapping our future

Over the years, we have been creating unlimited possibilities with geographic information systems (GIS). GIS is compatible with data in different formats. It is a data platform that supports the construction of a single source of truth (SSOT) for various large-scale infrastructure projects around the world. It enhances cost-effectiveness, and work efficiency as well as internal and external communications. GIS is one of the epoch-making innovative technologies.

2017

Joined hands with guests and clients to create a prosperous future at the opening ceremony of the 20th anniversary of the company

2019

Signed a memorandum of understanding with MTR to introduce GIS to the mass transportation industry, building a better future together

2021

Formally established a strategic partnership with Gammon Construction. By seamlessly integrating GIS with other smart technologies, we offered a variety of smart solutions to the building, engineering, and construction industries. It is a milestone in the digital transformation of Hong Kong's construction industry

Conclusion

In March 2021, the World Health Organization proposed a roadmap to improve indoor ventilation in the context of Covid-19 to reduce the risk of spreading the virus. However, the air that flows through outdoor and semi-outdoor areas, such as bus stops, stadiums, and playgrounds, is intricate. It is not easy to objectively evaluate whether there is enough airflow in these places.

In the past, this kind of fluid simulation required enormous computing resources, the related professional software could cost millions of dollars. In recent years, the Kyushu University of Japan has developed an application called Airflow Analyst, using computational fluid dynamics (CFD) to simulate the ventilation of outdoor and semi-outdoor spaces, combining the use of a geographic information system (GIS) to integrate data of a 3D city model, terrain, and building information modelling (BIM) to analyse airflow, and displayed the result on a map to make it clear at a glance.

Assessment of infection risk

During the Covid-19 pandemic, people were particularly concerned about the spread of the virus at major events. Therefore, the researchers used the Airflow Analyst to simulate how much fresh air would be obtained from the natural wind in Japan's National Stadium, the main venue for the Olympic Games in 2021. The computational simulation found that all the air inside the stadium would be replaced in about 13 minutes when a northerly wind with an average wind speed of 3 metres per second blows from outside the stadium, this means that the stadium gets new air approximately 4.6 times per hour.

Essence of liveable city

I am interested in this combination of airflow simulation technology with geospatial information, because it can show the change of wind direction on a 3D map, allowing people to evaluate the effect of fresh wind in semi-indoor and outdoor areas, thereby predicting and detecting the spread of the virus. In addition, there are broader applications in densely populated cities like Hong Kong in which serious heat island effects are not uncommon.

Under global warming, Hong Kong's high temperature often breaks records. For example, the average temperature of 2021 was higher than the normal. Coupled with exhaust gas from vehicles, it is very stuffy and hot at street level, especially when people have to wear masks. The problem is particularly noticeable in industrial districts, at the bus stations of the Cross-Harbour Tunnel, or in underground parking lots.

To build a liveable and pleasant environment and enhance walkability, architects can combine CFD with advanced technologies such as GIS, to assess the outdoor and semi-outdoor environment in the initial stage of the design which can ensure that microclimate elements are incorporated to introduce fresh air into the city instead of implementing remediation afterwards.

Commercialisation of research results

The CFD applications by the Kyushu University are examples of "GIS is everywhere" as GIS is a powerful and compatible platform for various types of data, with no need for users to switch between different interfaces.

This is also a showcase for how universities can commercialise their research results to benefit society, which is my wish for all startups.

In addition, to encourage startups and young people to use innovation and advanced technology to solve social and environmental issues, the government also has an important role to play here.

Government's role in nurturing startups

Take our neighbour Shenzhen as an example, the local government has set up a RMB¥10 billion (about HK$12bn) venture capital fund for early stage startups. With its fully market-oriented operation, it enables the city's new economy to thrive. The National Development and Reform Commission recognised its success and called on others to learn from it. Under the Covid-19 pandemic, Innovation Norway, a government agency to drive Norway's startup scene, invested more than NOK 3.2 billion (HK$2.7 bn) in startup companies younger than three years, doubling the amount in the previous year.

Therefore, I hope that the government can provide more financial support, so that Hong Kong people can truly experience the benefits of advanced technologies, and at the same time enhance the competitiveness of the city.

Epilogue: Inheritance

I have a humble wish for the publication of this book that the readers, especially teachers and young people, will be inspired by the local and overseas examples as well as the cases of 9 public and private organisations and government departments. I hope that they will gain insights into how spatial information improves a city's competitiveness and quality of life, and that they further think about how to capture the worldwide trend of digital transformation, so as to contribute to the development of Hong Kong and the Greater Bay Area.

References

Please scan the QR code for the references of the book.

SMART CITY 4.0

Author : Dr Winnie Tang

Coordinator : Jessica Yeung, Cristin Cheong

Source of picture : Airport Authority Hong Kong, Civil Engineering and Development Department, Environmental Protection Department, Food and Health Bureau, Hong Kong Air Cargo Terminals Limited, Hongkong Electric Company Ltd., Kadoorie Farm and Botanic Garden, Lands Department, Urban Renewal Authority, Esri China (Hong Kong) Ltd., iStock, Shutterstock, internet

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Dr Winnie Tang

Dr Winnie Tang, JP, is a locally born IT entrepreneur from Hong Kong. She is the Founder and Chairman of Esri China (HK) Limited, and the Founder and Honorary President of the Smart City Consortium.

She is also an Adjunct Professor in the Faculty of Engineering (Computer Science), the Faculty of Social Sciences (Geography) and the Faculty of Architecture at the University of Hong Kong (HKU).

Dr Tang specialises in geographic information system (GIS) and smart city technologies, and led the world's first SARS mapping and data analytics effort, which have become indispensable for timely and effective epidemic monitoring and response.

She is also keen to ensure the younger generations have better problem-solving skills and a stronger geospatial sense through a number of initiatives.

An e-learning programme Map in Learning was launched allowing primary and secondary school students in Hong Kong to use the professional GIS software ArcGIS Online for free. Over 220 schools have participated in the programme with training for over 1,700 teachers and students by the end of 2021.

She also started teaching master's degree courses on 'smart city' in various local universities, from HKU's Engineering Faculty, Social Sciences Faculty and Architecture Faculty to the Division of Public Policy of the Hong Kong University of Science and Technology, Lingnan University and the EMBA programme of the Chinese University of Hong Kong.

In addition, she has set up many scholarships and startup funds, aiming to unlock the potential of young entrepreneurs to serve the community.

Dr Tang has constantly shared her insights at international conferences organised by the World Bank Group, International Telecommunication Union and the Asian Productivity Organization. She has published 12 Chinese and English books and over 600 research papers and newspaper articles. Her Chinese books, *Surfing the IT World*, won the publishing award (the category of Commerce and Management) in the Hong Kong Publishing Biennial Awards 2017.

In recognition of her work, Dr Tang was awarded an Honorary Fellow by Lingnan University in 2020, a Distinguished Alumni by HKU Faculty of Science in 2009, the Ten Outstanding Young Persons award in 2006, the Women of Influence – Young Achiever of the Year Award by the American Chamber of Commerce in 2004 and the Ten Outstanding Young Digi Persons Selection in 2001.