IPS-Nathan Lecture Series:

SEEKING A BETTER URBAN FUTURE

Lecture II: ANTICIPATING OUR URBAN FUTURE
TRENDS, THREATS AND TRANSFORMATION

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10 April 2018
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Introduction

A few years ago, I was invited to speak at an International Planning Congress in Sydney. I was pleasantly surprised when the emcee introduced Singapore as 'The Rock Star City', and quipped that this is because Singapore is a 'very well-planned city'. What an accolade for Singapore given that just five decades ago, we were a city of slums and squatters. We have indeed come some way.

Singapore, at just 720 square kilometres, is about half the size of metropolitan London, and has a population of some 5.79 million people. We are land and resource constrained. Yet, in addition to the day-to-day facilities to support economic and social needs, we have to provide for major infrastructure requirements that enable us to function as an independent sovereign country. It is hard to believe that, on this little island, we house five airports, 17 reservoirs, several nature reserves, extensive land for military training, and one of the largest container ports in the world. Unlike London or New York, we have to provide for all these uses within our city. Despite our limitations, we have managed our urban growth reasonably well over the decades. For example, in 2017, Mercer ranked Singapore as the most liveable city in Asia.[1]

However, going forward, many changes both external and internal will pose challenges for us. What are these challenges, and how well are we anticipating them, so as to build an attractive urban future with a good quality of life?

Challenges

Maintaining Economic Growth and Competitiveness

Singapore has enjoyed sustained economic growth since independence. Incomes have risen, and resident unemployment rate has remained low by world standards, at around 3 per cent. Nevertheless, as highlighted in the report by the Committee for Future Economy last year, any subdued global growth, and rising anti-globalisation mood and protectionist economics would hurt a small, open economy like Singapore's.[2] Remaining relevant and competitive, and tapping on new opportunities for growth is an imperative for us. Hygiene factors like good governance and

[1] In Mercer's 2017 Quality of Life Ranking, Singapore was ranked 25th globally, and first for Asian Cities, offering the highest quality of life, and its infrastructure was deemed one of the best in the world. https://www.mobilityexchange.mercer.com

[2] Committee for Future Economy Report.

stability, availability of skills, a safe and a friendly business environment continue to be important. On the physical aspects, we have to ensure that we remain an attractive and competitive city for businesses—with adequate space, reliable utilities and infrastructure, state-of-the-art connectivity (physical and virtual) and high liveability, in order to attract investments and talent, and to grow business opportunities.

Mitigating Climate Change

The earth's climate is likely to change dramatically over the next century. Increased occurrences of extreme weather events, desertification and rising sea levels all directly threaten the world's cities. 15 of the world's largest cities are located in coastal zones threatened by sea-level rise and storm surges.

Singapore is not exempted from climate change. According to Singapore's Second National Climate Change Study, there has been a general uptrend in annual average rainfall from 2192 millimetres in 1980 to 2727 millimetres in 2014. Based on Phase 1 of the study, the long-term effects of climate change would lead to a temperature increase of 1.4°C to 4.6°C and a rise in sea level by up to about 1 metre by the end of this century.[3]

Sea-level rise poses the most immediate threat. Much of Singapore lies only 15 metres above mean sea level, with about 30 per cent of our island being less than 5 metres above the mean sea level. Periods of drought can affect the reliability of our water supply, while sudden episodes of intense rainfall could overwhelm our drainage system and lead to flash floods.

A mean temperature increase of 1.5°C to 2.5°C could affect the natural diversity of Singapore's plants and put animals at risk, as this alters our ecosystem's natural processes, such as soil formation, nutrient storage and pollution absorption.

Warmer temperatures mean that more vector-borne diseases like dengue could become endemic and more people would suffer from heat stress. Urban areas will become warmer as natural land cover give way to buildings and other infrastructure that retain or produce heat. This induces the

[3] Second National Climate Change Study by the National Environment Agency.

'urban heat island effect'. Increased use of air-conditioning would lead to higher energy demand and carbon emission.

The effects of climate change such as intense storms, floods or prolonged droughts will also threaten global food security. Singapore is particularly vulnerable to fluctuations in global food supply and prices as we import more than 90 per cent of our food.

Even as we continue to urbanise, strengthening our resilience and finding solutions to protect our city from the effects of climate change is critical.

Preparing for an Ageing Population

Singapore faces the twin demographic trends of declining birth rates and an ageing population. Our Total Fertility Rate (TFR) has been below that needed to replace ourselves since 1977. TFR in 1976 was 2.1, dropping to 1.8 in 1977, staying below replacement ever since. By 2030, one in four people, or about 900,000 people, will be aged 65 and above, double the current number. The resident old-age support ratio will fall from 7.5 in 2010 to a projected 2.1 in 2030 based on the current fertility rate, and if there is no introduction of new citizens.[4] There has been much discussion on whether these demographic trends will impact negatively on Singapore's economic and social vibrancy, and how the impact could be partially mitigated by the longevity dividends[5] accruing from a more productive senior workforce and new 'silver hair' industries.

Be that as it may, what is certain is that, as our population ages, we need to enable the elderly to remain physically healthy, economically active, and engaged within the community so that they can stay independent for as long as possible. Our physical environment needs to be designed for a more elderly society with sufficient and appropriate supporting facilities for them.

Managing Technology Disruptions

We are in the midst of a technology revolution that is changing how we live, work and relate to one another. There are many scientific breakthroughs and new technologies being generated. I

[4] National Population and Talent Division Occasional Paper dated April 2012.

[5] The Institute of Policy Studies' Singapore Perspectives 2018 Conference Background Paper. "Harnessing Singapore's Longevity Dividends: The Generational Economy, Society and Polity". http://lkyspp2.nus.edu.sg/ips/wp-content/uploads/sites/2/2017/11/SP2018-background-paper_180118.pdf

have selected a few that will impact more directly how cities are planned, developed and managed.

(a) Big Data Analytics, Sensors and the Internet of Things (IoT)

Klaus Schwab, founder of the World Economic Forum, wrote in his book, *The Fourth Industrial Revolution*, that we are now undergoing a fourth industrial revolution which 'is characterised by a fusion of technologies that is blurring the lines between the physical, digital and biological spheres'. Recent advances in information and communications technology (ICT), such as the Web 2.0, cloud computing and sensor networking have made it easier for the Internet of Things (IOT) to acquire, organise and process vast amounts of information. This information can be used to monitor and control the function of urban systems, and increase the efficiency and reach of urban services. It can help a city's residents, communities, leaders, and other stakeholders to become more informed and involved, and radically change how cities and homes are managed.

Many consumer technology companies are already moving into the smart home market. For example, Apple released its self-installed smart home ecosystem called Apple Home, and Google launched Google Home in 2016, a brand of voice-activated smart speakers. These systems deliver innovative building automation and energy management that maximise comfort, environmental quality and sustainability.

Artificial intelligence (AI) will enable intelligent systems to collaborate effectively with people and to teach robots through machine learning. Pervasive robotic technology will provide indispensable support as our personal assistants and helpers in everyday life, offering wide application in the services, industrial, military, construction and medical sectors. For example, human augmentation technology (HAT) is increasingly used in Japan in healthcare as the population ages. AI will dramatically transform the way we live, work, move, and play, and we—as a society, nation, and city—need to be ready for this future.

(b) Next generation mobility

Digitisation and real-time information will make vehicular traffic more efficient, and allow an unprecedented monitoring of urban mobility infrastructure. Autonomous vehicles will transport goods and people more efficiently and safely than manned vehicles over time. Each new autonomous vehicle is projected to replace ten cars. The hope is that this will alleviate road

congestion. If they are electric vehicles, oil use and attendant green-house gases can be reduced by 71 per cent.

Airborne vehicles are also being explored in several countries. In 2016, Amazon famously patented a flying warehouse to dispatch drones from the sky. Another recent patent proposes a 'hive-like fulfilment centre' for drones. These multi-layered warehouses will be optimised for urban areas, occupying less land than the company's current single storey buildings.

Unmanned aerial vehicles can be programmed to deliver items such as food and medicines to homes, communicate with the power grid, and gather information about traffic, flooding, and other helpful data. Drones facilitate last-mile delivery, and may lead to a blurring of line between retail and logistics space, by holding warehousing and delivery functions.

Drones could one day be used to transport people too. Uber is partnering NASA on its flying taxi project called Uber Elevate, which they are aiming to trial in Los Angeles, Dubai and Dallas-Fort Worth in 2020.

Such new technologies for movement will require us to rethink how we plan the city. For example, can we free up more road and traditional parking spaces, and repurpose them for other uses? Urban logistics will transform with AV trucks delivering goods at off-peak periods to reduce congestion. On the other hand, we need to address potential congestion caused by increased freight volumes as a result of last-mile smaller deliveries arising from e-commerce. In addition to roads, we may now need to set out new regulations and pathways for drones to fly safely in the city.

(c) The Sharing Economy

On a broader scale, technology-enabled platforms like a smart phone and websites make possible what is now called an 'on-demand' or a 'sharing' economy. These platforms can match supply and demand in a very accessible and low cost manner, creating entirely new ways of consuming goods and services. For example, Airbnb facilitates the renting out of homes for transit stay, and now has 150 million guests, threatening the hotel and hospitality sectors.

Uber and Grab have completely disrupted traditional taxi transport. Didi Chuxing in China operates 25 million daily rides driven by around four million drivers. Collection of data by their drivers enable Didi to use AI to even predict where riders are likely to want cars 15 minutes ahead of time, guessing it right 85 per cent of the time and even learning the preferences of its passengers.[6]

Workspaces can now be optimised and shared through co-working and flexible rental, reducing the need for traditional office space. In London, co-working spaces in 2016 accounted for some 8.8 per cent of the total take-up of space.[7] Demand for co-working spaces is expected to expand at an average rate of 10 to 15 per cent annually.[8] Global players like Wework are expanding in various cities. There are also numerous home grown operators like JustCo, Spacemob and Working Capitol, each trying to differentiate themselves through themed interiors and workstations. The current sector definitions of office, retail and industrial space will become more blurred, with more mixed uses co-locating together as the nature of businesses changes. Developers and planners need to become more flexible and inventive to cater to these changes.

Online e-commerce has also impacted the retail scene, and is putting pressure on traditional retail shops and malls. To attract footfall, stores now have to be an 'experiential hub' that provide entertainment and community offerings. Apple is a leader in this strategy—its stores are always packed with consumers testing products and interacting with store associates. Apple has even renamed its stores as 'Town Squares' where people get together for events, classes and entertainment.

At the same time, online retailers like Alibaba and Amazon are adopting a 'new retail' strategy where they establish an offline presence by opening stores and pop-up spaces to test markets, get new product feedback, or simply drive conversion towards buying specific products.[9]

[6] James Crabtree, Wired UK, 'Didi Chuxing took on Uber and won. Now it's taking on the world'; 9 February 2018.

[7] Source: www.cushmanwakefield.co.uk, February 2017.

[8] Co-working report by Cushman & Wakefield and Corenet Global, 2017.

[9] Source: https://asia.uli.org/programming/uli-hong-kong-tenant-future-uli-x-fgrt/

Online shopping has changed the logistics sector as the industry needs to get parcels delivered quickly to buyers. Spaces have to be allocated for buyers to collect and return parcels conveniently.

Addressing the Geo-Socialisation Trend

Geo-Socialisation has been cited as the next trend in social networking.[10] This is a geographically based type of socialisation where social networking will rely on geographic services and capabilities such as geo-coding and geo-tagging to allow social networks to connect users with people or events that match their interests, resulting in a more customised way of networking. For example, people can join in a group chat at a sports event.

Businesses can also respond to real-time demand to cater to customers who react to geographically tagged services. For example, your mobile phone will point out interesting places, shops and restaurants near you based on data on your user preferences, including receiving updates on promotions. This will drive new trends in digital marketing, socialising and networking. Interaction between individuals and organisations will further evolve through the use of Virtual Reality (VR) and Augmented Reality (AR).

Pokémon Go brought AR into the mainstream. Google's Tango platform and Lenovo Phab 2 smart phone's AR features allow the phone to see and map the world around you. AR can allow you to measure the size of a room and move virtual furniture around. VR will shake up retail. For example, Alibaba has launched a VR store called Buy+ that allows shoppers to wander a VR mall complete with big name stores. Such technologies could further reduce the need for people to shop in a physical store.

With social networking, it also means that interactions are no longer limited by physical boundaries. From a social perspective, it requires planners to understand and redefine who 'neighbours' really are, and to think of new ways to promote communities and social bonding.

[10] Source: Frost and Sullivan, www.growthconsulting.frost.com.

Planning in an age of rapid change and uncertainty

These trends and disruptions are all converging on Singapore. What should be our urban responses to them so that we continue to be a liveable, resilient and dynamic city? In this lecture, I would like to raise some strategies for us to think about. I appreciate that many of these are already being studied by the various government agencies. Nevertheless, by highlighting more holistically many of the on-going efforts and through a sharing of ideas, I hope to contribute to a greater awareness of what it takes to anticipate needs and prepare Singapore for a better urban future.

Where are we today?

I highlighted in my first lecture that successful cities have shifted away from the traditional blueprint plans to a long-term strategic planning approach. More importantly, successful implementation depends on the formulation of detailed implementation plans, which are then embedded in an institutionalised structure in order for these plans to be executed.

Today, Singapore already adopts a long-term strategic planning approach. It is crucial that Singapore takes a long-term view when it plans. Given our land constraints, we need to develop strategies that will safeguard sufficient land to meet our development needs way into the future.

We now formulate strategic 'Concept Plans' with a long-term perspective of 40 to 50 years. Such plans focus on the strategic broad strokes rather than details, attempting to safeguard land for all the major land uses and key urban infrastructure (especially transport infrastructure) to support growth. The Concept Plan is reviewed roughly every 10 years to keep pace with changing needs, with additional reviews done by agencies internally where required. So far, four Concept Plans have been prepared in years 1971, 1991, 2001 and 2011. Phased medium-term plans are also worked out to help decision makers make the necessary trade-offs between competing land uses and to prioritise infrastructure investments to support physical growth.

The Concept Plan is cascaded to a statutory detailed Master Plan with a shorter horizon of about 15 years. The Master Plan maps out detailed land uses and the maximum plot ratio or density allowable for each site, and is reviewed every five years. The legislated Master Plan provides transparency and certainty to the private sector to guide their development and business decisions.

The formulation of the Concept Plan is a highly complex exercise which requires a 'Whole-of-Government' effort. Inter-Ministry committees are formed, looking into matters of population, housing, transportation, commerce and industry, central area planning, environment and recreation. The plans are not static; the assumptions and projections are revisited regularly and the strategies adjusted where necessary. This 'Whole-of-Government' approach is critical as urban issues become increasingly complex and difficult trade-offs have to be made. The formation of the Prime Minister Office's Strategy Group is also timely, to identify and coordinate national priorities early and to translate them into policy action plans.[11] This institutionalised process has been a key factor in enabling many of our plans to be realised.

Going forward, what might be some strategies which we could consider in planning for our future? Let us examine some of these.

1) Adaptive Lifecycle Planning

Singapore is in transition into 'early middle age'. As our island becomes more built up in the next few decades, how can we secure land for future development?

I would like to introduce the idea of '**adaptive lifecycle planning**'—a concept of creating a virtual cycle of land recovery, thus enabling a constant rejuvenation of Singapore for future generations. Let me expand on this concept.

1. 1) Rejuvenation through Recycling Land

Similar to many mature cities, as we become built up over time we will be left with more brownfield rather than greenfield sites. This requires us to shift progressively into an 'urban redevelopment/regeneration' mode. For an island city-state limited by our territorial waters, available land for new development will come mainly from 'recycling' existing land and properties.

Given this, perhaps our long-term planning horizon should be stretched beyond the Concept Plan's current 40 to 50-year horizon to even 100 years to capture opportunities for potential

[11] The PMO Strategy Group covers multiple policy areas such as strategic planning and futures, social, economic, land and liveability, population planning, marriage and parenthood, security and resilience, climate change, talent engagement and integration.

redevelopment beyond the economic and useful lifespan of existing buildings and infrastructure. By doing so, we would be able to secure land for rejuvenation to meet the needs of future generations. Some may say that this proposal runs counter to the need to be flexible in a very uncertain world. However, I would argue that 'lifecycle planning' would stretch our imagination and open us to future possibilities. If we think sufficiently long-term, the fixed constraints today, even large existing developments like airports, would be sufficiently depreciated in the longer-term to allow for major moves in our plans. Taking a longer-term view will also enable us to factor in the investments needed for costly infrastructure so that we can build up our fiscal resources over time. Of course, the plans would have to be reviewed regularly to respond to dynamic changes.

Our system of leasehold land is key to enabling such land rejuvenation to take place. For example, industrial land which are generally on 30 to 60 year leases can be recovered when their lease ends. The land can then be re-used to meet new needs and support new economic thrusts in the next lease cycle.

We see many successful examples of such urban regeneration in the world. For example, London and Bilbao are examples where port land, which is no longer needed, is redeveloped for new commercial, residential and cultural uses.

Similarly, we are re-locating a large part of our port after some 50 years. PSA announced last year that it would be moving its Tanjong Pagar terminal to Pasir Panjang soon and eventually, to the Tuas mega port. This new state-of-the-art port is slated to be operational from 2021 and fully ready by 2040. This shift will eventually free up much of the southern waterfront for future residential, commercial, and leisure and recreational opportunities. In another example, the move of the military airbase at Paya Lebar to Changi in the future will free up 800 hectares for new developments.

These 'musical chair' moves are an essential strategy for rejuvenating our physical landscape. But to make changes to spatial patterns, we have to plan well ahead of time. A few large pockets of land need to be safeguarded to initiate these big moves.

1.2) Build Adaptability into Our Planning

Being **adaptable** means that we should provide for 'modularity and flexibility' in our plans, in view of future uncertainties. For example, even though we have safeguarded a large tract of land in Tuas for our port, it could be phased to retain strategic flexibility, in case demand for port activities does not pan out as envisaged.

Building flexibility into our plans also requires us to develop plans which can accommodate a larger population. Dr Liu Thai Ker has advocated planning for a projected population of 10 million.[12] His view has generated debate. No doubt, there will continue to be much discussion on what might be an appropriate population size for Singapore. This largely depends on whether we can find innovative urban solutions to sustain our good living environment, and on the level of acceptance by our citizenry.

Regardless of public sentiments, it is wise to plan for scenarios with varying population sizes, as it would help planners to anticipate the types of infrastructure that will be needed, the appropriate densities to build on available land, and to work through the many difficult trade-offs in allocating land amongst competing uses. If the population growth does not materialise, we would have a happy situation of having more land buffer set aside and more choices in the use of land.

1.3) Develop 'no regrets' infrastructure and pursue land/space creation

When future demand is uncertain, how should we provide hard infrastructure which, once built, cannot be changed? One strategy is to plan for and invest in selected 'no regrets' infrastructure upfront, even if it might result in some redundancy and sub-optimisation. One example is the MRT rail network. Planning for more rail lines in anticipation of a larger population would enable us to safeguard the land for the rail corridors now before the city gets more built up. In fact, this was how we managed to build many of the existing MRT lines today. Our long-term planning approach meant that we had safeguarded the land corridors for many of our MRT lines since the 1970s. Sizing upfront a capacity with sufficient buffer for growth is an important consideration because once the railway line and MRT station is built, any attempt to upgrade capacity is extremely costly, if not impossible.

[12] Liu, Thai Ker. "'Intelligent Planning in Singapore: Practice and thoughts; Challenges and Reforms in Urban Governance." In *Challenges and Reforms in Urban Governance: Insights from the development experience of China and Singapore*. Singapore; Centre for Liveable Cities, 2016.

A second example is land creation—where possible, we should build up a land bank because in Singapore's context, 'more land is better than less land'. An illustration of good planning foresight is the reclamation of land at Marina Bay since the 1970s in anticipation of the future growth of the city. This alleviated growth pressure on the existing city, and enabled us to conserve many of our historic districts. However, the extent to which we can reclaim land is limited by our territorial boundaries as we have to also preserve sea space to support our port functions. We should therefore explore other means of space creation as well.

JTC has successfully implemented the Jurong subterranean caverns for liquid storage. The government is looking into the development of more underground space. Opportunities exist in areas like the ground beneath Kent Ridge or the Science Park where the soil formation underneath is suited for such underground construction. In collaboration with partner agencies, the Urban Redevelopment Authority (URA) is currently developing an Underground Master Plan, which it said will be announced in 2019.

We could also consider decking over large swaths of transport infrastructure, such as highways and MRT depots that take up extensive tracts of land. There are many successful examples where this has been done. Klyde Warren Park in Dallas was created by decking over highways. The Millennium Park in Chicago and the new park at Hudson Yards in New York straddles a working railyard.

Co-locating uses can also save land. The East Coast Integrated Depot, a new 36-hectare $3.2 billion depot will be built to house 220 trains for the Thomson-East Coast Line, East-West line and Downtown line. Said to be a world's first, the depot will also house 550 buses. By integrating the depots, the Government expects to save 44 hectares of space, or about 60 football fields. It will be completed by 2024.

This strategy uses '**capital and technology**' to overcome our limitations in land. The challenge is to find the right economic model to justify these expensive investments. For example, we were able to justify sinking the Marina Coastal Expressway underground because it would free up more prime land with access to the waterfront, and enhance overall land value. Similarly, decking over

infrastructure use would create additional space and free up land elsewhere for other uses. Such projects should be seen as investments in our future.

1.4) Build in Greater flexibility in Regulations and Design

Planning regulations convert our land use plans into working rules to steer developments towards specific planning objectives. Being adaptable is about building in more flexibility to our zoning regulations to cater to the changing work patterns and market needs arising from the sharing and the digital economy. When we planned Marina Bay, we introduced the 'white site' zone where we stipulated a minimum floor space for a specific use, such as a hotel, and then left it to the market to determine the remaining types of uses according to demand. The type of use could also be changed over time to meet evolving needs. More white sites could be considered as we open up newer mixed-use areas.

Recently, URA introduced an innovative zoning approach for the new Punggol Digital District—a district set aside for digital and cyber-security industries. Zoning rules would be applied at a district level instead of on individual parcels of land, giving developers more flexibility to mix uses.

Just as cities need to be adaptive, so should buildings be designed for greater flexibility. Reasonably sized floor plates, wider structural spans and sufficient floor to ceiling heights would allow a building to be converted and repurposed for a variety of uses over time. For example, Google's new Mountain View headquarters comprise a series of giant domes under which any number of structures, fit for any purpose can be quickly assembled, making it completely programmable for any use case.

2) Infrastructure as an Integrated, Resilient and Intelligent Urban System

2.1) Develop an Integrated National Infrastructure Plan

Many mature cities are ageing and suffering from a huge infrastructure gap. London recently established the London Infrastructure Development Body (LIDB) to formulate the £1.3 trillion London Infrastructure Plan 2050, catering to an anticipated growth in London's population by 3.1 million between 2011 and 2050. This plan creates an integrated vision for London, encompassing sectors such as transport, green infrastructure, digital connectivity, water, energy and social infrastructure, and is the first ever attempt to identify, prioritise and cost London's future

infrastructure to 2050.[13] London also has an independent National Infrastructure Commission which advises the government on infrastructure development. It carries out assessments on the state of infrastructure, and takes a strategic approach by linking long-term priorities with short-term actions, so that infrastructure is seen as a system and not as a collection of silos.[14]

Today, based on our Concept Plan's projections, individual agencies make provision for key infrastructure such as those covering transport, water, energy generation and waste management. Going forward, there is scope to rethink infrastructure as 'urban systems' and not just as specific stand-alone types of infrastructure, so that we can achieve closer integration and greater synergies between them.

As a small island city-state, we should work towards three important principles in our infrastructure provision:

a) To favour a **circular rather than a linear model**;

b) To adopt an **integrated multi-function rather than a single function system;**

c) To build **resilient and intelligent urban infrastructure**.

This integrated way of developing infrastructure would support Singapore's National Climate Change plans to address climate change through a 'whole-of-nation' approach. The strategies include reducing emissions across sectors, building capabilities to adapt to the impact of climate change, harnessing green opportunities as well as forging partnerships on climate change action.[15]

One of the best examples of a circular system is the way in which the Public Utilities Board (PUB) has successfully closed the 'water loop'. Today, Singapore is designed as 'one giant, rain-water

[13] Source: https://www.weforum.org/reports/inspiring-future-cities-urban-services-shaping-the-future-of-urban-development-services-initiative

[14] Source: https://www.nic.org.uk

[15] See National Climate Change Strategy Report by National Climate Change Secretariat, PMO.

absorbing sponge'. PUB has developed a whole network of drains, canals, and underground storage tanks to capture rainfall. Through the introduction of the Deep Tunnel Sewerage System, PUB is also capturing all used water and is recycling it into NEWater, most of which is used by industries that require very clean water.

In our storm water management, we have started to 'green' grey infrastructure by introducing more sustainable alternatives, using absorbent green spaces and wetlands for flood defence, even as they create recreational and aesthetic value. Bishan-Ang Mo Kio park and the Housing Development Board (HDB) parks and ponds in Bidadari and Tengah towns all help to hold back water discharge after a heavy rain. In addition, the plants help to cleanse the water before they are discharged into drains and reservoirs, thus reducing the cost of water purification.

Our urban infrastructure should also act as a network of elements which is integrated and multi-functional, rather than serving a single function. Facilities could be creatively co-located to serve multiple uses. For example, Rotterdam, where certain neighbourhoods are as low as 6 metres below sea level, pioneered the construction of facilities like parking garages that become emergency reservoirs. Its dykes at Dakpark are integrated with other land uses such as a shopping centre and parking garage, enabling the integrated facility to build one of the largest roof parks in Rotterdam.

Similarly, we should think of 'multi-functional' strategies in say, land reclamation. For instance, in the future reclamation of land along the East Coast and the Southern Waterfront, the reclamation could double up as a 'dam'; a coastal protection measure that protect the inland low lying areas along the East Coast. The reclaimed land could also be shaped to create more inland waterbodies where heavy rainfall could be channelled into, to prevent floods and double up as freshwater storage areas. These waterbodies would create more waterfront conditions which also provide opportunities for more beautiful waterfront housing and recreational areas.

2.2) Strengthen Waste-Energy-Water Nexus

We should pursue integrated infrastructure solutions that combine energy, waste and water as they have the potential to provide benefits across multiple city systems. For example, while PUB has successfully recycled used water, the process consumes large amounts of energy. A recently

announced PUB-National Environment Agency (NEA) project is a good example of how the waste-energy-water loop can be tapped to address the energy issue.

This is a $9.5 billion project comprising PUB's Tuas Water Reclamation Plant (TWRP) co-located with NEA's Integrated Waste Management Facility (IWMF), which will enable Singapore to reap the benefits of a water-energy-waste nexus while minimising land footprint. Essentially, electricity generated at IWMF from the incineration of trash will be supplied to TWRP for its operations. The TWRP will purify used water, transported from the existing Deep Tunnel Sewerage System, into NEWater and industrial-grade water for reuse. At the same time, the de-watered sludge from TWRP will be incinerated at IWMF for electricity production. Food waste and used water sludge will also be co-digested, through a process called anaerobic digestion, where micro-organisms convert waste into biogas to enhance the overall thermal efficiency and electricity production at IWMF.

2.3) Intelligent infrastructure

We should combine engineering and data to enable a more intelligent approach to infrastructure so that we optimise energy generation and distribution, make our buildings smarter and keep traffic flowing. Advances in sensors, controls and software can enable:

a) Increased intelligence and transparency, providing the right information at the right time for informed decisions. With artificial intelligence we can move beyond normal monitoring of services towards predictive maintenance, where we can anticipate a problem and fix it before the service is affected.

b) Integration: information can be shared across systems and organisations to eliminate silos and optimise performance. For example, Smart buildings can take on energy when it is cheap and plentiful, storing it first and then feeding it back to the grid when demand is high, thus optimising the use of energy.

Today, Singapore's infrastructure ecosystem, whilst efficient, may not be fully optimised. The above linkages between various infrastructure systems suggest that there may be merit to consider the development of a **National Infrastructure Plan** to ensure that our long-term plans and vision are supported by timely infrastructure that takes a systems approach. Such a plan

would help to further identify specific opportunities to synergise the various urban systems: food, energy, waste, water, transport and greenery, and to close the material and energy cycles to create a circular ecosystem.

3) Deliver Well Managed and Liveable Density

With a growing population, living density in Singapore will increase from 11,000 persons per square kilometre to 13,700 persons per square kilometre between now and 2030. However, we need not fear densification if it is done well.

Densification takes place in cities because higher densities enable cities to absorb more people. Dense cities become engines of economic growth because they offer a larger market size for projects, attract talent for greater innovation and provide the support and connectivity needed for businesses to thrive. From a sustainability point of view, denser and compact cities also use less energy,[16] are more walkable and help to make public transport options, waste disposal and management services more viable and efficient to operate.

However, this is not to say that we densify without thought. Optimal density needs to be 'appropriate' and involves deliberate and decisive spatial planning and design strategies that continues to make a city highly liveable. The following are some ways that can help to create liveable density.

3.1) Constellation of Commercial Centres to rebalance the Urban Pattern

To support economic growth, Singapore has developed two distinct economic hubs over time—our Central Business District (CBD) and the manufacturing hub in the west—which house some 70 per cent of our economic activities. Since Concept Plan 1991, we have adopted a 'constellation' of decentralised alternative affordable spaces for commercial growth outside the city to reduce traffic congestion in the city centre. As a result, today we have Tampines Regional

[16] The Global Commission on the Economy and Climate states that `more compact, more connected city forms allow significantly greater efficiency and lower emissions per unit of economic activity.' (http://newclimateeconomy.report/wp-content/uploads/2014/08/NCE_GlobalReport.pdf). Lower density cities in the United States (typically ten persons per hectare or less) uses about 5 times more energy per capital in gasoline than then cities of Europe, which are in turn about 5 times denser on average'. (http://uli.org/wp-content/uploads/ULI-Documents/10PrinciplesSingapore.pdf).

Centre, which hosts many of the backend functions of banks and new commercial sub-regional hubs like Paya Lebar and Novena, contributing to a better job to home ratio in the various regions.

Nonetheless, there is still high one-way travel demand from across the island towards Central Area and the West Region during peak hours. To reduce congestion and shorten commute time, URA and LTA are stepping up decentralisation efforts with a newly coined `polycentric' approach. With more public housing being built in areas like Woodlands, Yishun, Punggol, and in Jurong, there are opportunities to shift more commercial activities and jobs to newer areas. For example, to the north, we have the upcoming Woodlands Regional Centre, the North Coast Innovation Corridor which will include the Punggol Digital District and the new Singapore Institute of Technology (SIT). To the west, the new high speed rail terminal at Jurong Lake will catalyse the expansion of the Jurong Lake District Regional Centre into a new major western commercial node. These commercial nodes will be well-designed, mixed-use environments with amenities and more affordable rents, providing alternative premises for businesses.

The western region will host the new PSA mega port in Tuas, and the Jurong Innovation District near Nanyang Technological University (NTU), providing more employment opportunities in these areas. In turn, more housing will be injected back into the Central Area with new opportunities for development at the southern waterfront, Marina Bay and Marina East. This will improve the job to home ratio, and reduce cross island travel.

3.2) Rethink Urban Mobility

Land use planning must be supported by a good transport system. We have all along adopted a 'transit oriented' approach by encouraging the use of public transport that serve higher density nodes. Singapore was one of the first cities to put in place policy measures such as the Certificate of Entitlement (COE) car quota scheme and the electronic road pricing in the 1970s to moderate car growth and to manage traffic congestion. Nonetheless, roads today still take up about 12 per cent of land—almost as much as the 14 per cent of land used for housing. To keep increasing the car population, which would in turn consume more land for roads, is simply not sustainable. In fact, Singapore's private transport mode share is 34 per cent in 2014, which is higher than Seoul (23 per cent; 2013), Tokyo (12 per cent; 2008) and Hong Kong (12 per cent; 2011), where more

people use public transport.[17] LTA has therefore set a target to improve our public transport mode share during peak periods to 75 per cent by 2030.

We must pursue alternative transportation modes beyond the car. In an interview in 2017, Ford's CEO Mark Fields said that 'the future of cities has almost nothing to do with cars… The real problem is how to prepare for a future in which people prefer to get around using all different modes of transportation: driverless cars, ride-sharing, train, bus, bicycle and on foot'.[18]

In Singapore, there is now a big push towards a 'car-lite' society. Last year, LTA announced that it will adopt a zero car growth policy. The idea is to shift increasingly towards 'mobility as a service', rather than having individually owned cars. LTA is piloting car sharing and AV vehicles to yield greater efficiency and safety so that road space can be reduced. Car parking supply are being tightened, particularly within the city core. Last year, URA exhibited possible ideas for future neighbourhoods at Bayshore and Holland Plain, and architects have mooted the idea of reducing car parks by 50 per cent in those districts.

A 'car lite policy' will need to be supported by alternative affordable and convenient modes of transport. LTA is investing heavily in rail and doubling the rail network from 178 km to 360 km by 2030.[19] LTA has also added on a larger fleet of some 1,000 buses.

Many kilometres of cycling tracks are being developed to encourage more people to cycle. In 2017, LTA passed the Active Mobility Bill to allow the use of bicycles and Personal Mobility Devices (PMDs) on public paths. We now have bike sharing too. It is still early days to conclude whether cycling will take off in a big way and whether we can get the cyclists, pedestrian and drivers to co-exist harmoniously. In the meantime, the cycling network will continue to be expanded to improve convenience and connectivity.

[17] Source of overseas data: LTA Academy, Journeys, Nov 2014.

[18] Business Insider, 1 Feb 2017. Ford created Ford Smart Mobility in March 2016, bought Chariot, a San Francisco based shuttle service' and also partnered with bike sharing company Motivate to launch its own bike-share service by end 2017.

[19] The Land Transport Authority's Land Transport Master Plan 2013.

To further reduce congestion, there is a need to explore more sustainable urban logistics solutions too. JTC is looking at incorporating a central distribution centre at Jurong Innovation District (JID) where goods are stored and handled, and a dedicated road network for the delivery of goods to companies. The government is also looking into an island wide federated parcel locker network to ease the last-mile delivery challenges.

There is likely to be increasing use of unmanned aerial vehicles (UAV). For example, Airbus's Skyways project aims to provide efficient, seamless delivery of small parcels via drones across the National University of Singapore Campus. Such initiatives require us to consider designing cities that cater to 3D mobility which includes safe pathways and landing for UAVs and regulations to ensure safety. In fact, NTU's Air Traffic Management Research Institute (ATMRI) is developing a traffic management system for drones called the Traffic Management of Unmanned Aircraft Systems. Air traffic lanes are designated by using 'virtual fences' to reroute drones around restricted geographical locations, thus enabling hundreds of UAVs to fly efficiently and safely at any one time.[20]

3.3) Build A City of Greenery and Water

Our agencies, such as URA, National Parks Board (NParks), PUB and HDB have done much to achieve a finely balanced urban development, complemented by lush greenery and waterbodies throughout the island. There are some 360 parks today and more will be built. At a national level, we have safeguarded large swathes of nature reserves right in the heart of the island and national parks such as the Botanic Gardens and Gardens by the Bay within the city centre. The new Jurong Lake Gardens will be the first national garden within the HDB heartlands and next to the new western region commercial node.

We are constantly creating the 'illusion of space' through innovative 'multiplication' effects. For example, URA successfully created a large linear hill park simply by connecting Mount Faber and Kent Ridge Park with interesting bridges which straddle over roads. Our park connector network has enabled greater access to cycling and jogging trails, with links to multiple parks and coastal areas.

[20] Source: Media.ntu.edu.sg/NewsReleases, 28 Dec, 2016.

The rail corridor will soon become another well-loved space for a quick get away from the hustle and bustle of the city. Imagine the possibility of linking the rail corridor with surrounding attractions with historic areas and parks, with offshoots to interesting neighbourhoods, food havens, nature and biodiversity areas. It would indeed be a creative way to expand our leisure space multi-fold in this small island.

At the building level, we are replacing the greenery lost to developments on the ground through the creation of new land by way of sky terraces and sky gardens. Water elements are weaved into the urban scape using water sensitive urban design comprising bio swales and rain gardens. By planting the right plants, we are bringing back greater biodiversity and attracting the return of wild life such as otters, hornbills and other birdlife.

3.4) More Edible Gardens and Urban Farms

One area that we could explore is to increase the amount of food produced in Singapore. Aside from more productive commercial farms, we could explore urban farming by the community. Recently, NParks has announced that it would encourage more to adopt edible gardening, planting edible fruits and vegetables. HDB, in its planning of the new Tengah town, has weaved in large linear greens. We could explore the introduction of small scale urban farming, roping in community groups and social enterprises.

3.5) Develop ‘People Cities’ using Excellent Design

Successful liveable and distinctive cities are ‘people-focused’. They go beyond functionality to build identity, image and a great environmental quality through good design. We need to develop a pervasive culture of design excellence from macro urban design to the smallest details of a building and city infrastructure. A well-executed juxtaposition of high and lower blocks can provide both relief and a more interesting and distinctive skyline for the city. Well-designed high density developments interwoven with landscaped greenery, water bodies and public spaces, conveniently served by facilities can produce a high quality living environment.

Great public spaces encourage community interaction and activities and bring vibrancy to a city. Beyond the design of great public spaces, we should promote effective place-making and programming to encourage greater vibrancy and community interaction. We have already been

successful in generating much activity in areas like Marina Bay and the Civic District. Roping in stakeholders to take ownership of place making activities is essential to sustain such activities.

Good urban design will help to shape a good environment and enable us to plan well for an aging population. We need to embrace universal design, mixed uses and new typologies to enable convenient movement, access to facilities and promote social interaction. I will cover more of this issue in my next lecture.

I would also appeal for greater attention to be paid to the quality of design of our public spaces and urban infrastructure. Increasingly, our urban infrastructure is creeping into our crowded streetscape, and if we are not careful, could mar the visual experience of our city. Careful attention must be paid to the design of larger urban structures such as the increasing numbers of ventilation buildings and MRT stations and entrances. There are also miles of overhead ramps, pedestrian bridges, link ways and multiple signages that crop up along a street. We need to bring some order to these as we experience a city largely at the street level.

We can take a leaf out of cities that have lovingly nurtured a design culture that looks at all aspects of public infrastructure. For example, Bilbao commissioned Norman Foster to build the signature 'fosteritos' that are the entrances to all its subway stations. Barcelona has attractive boulevards such as Passeig de St Joan Boulevard, where the scale and design of sidewalks, trees, signages, lamp posts and street furniture are all beautifully coordinated. Transport can be beautiful if we put some thought into careful design before we build.

To be a people-oriented city, we also need to be mindful of conserving built heritage to retain social memories. In the case of Singapore, it is a difficult balance in deciding the extent to which we should keep built heritage and places while ensuring we have sufficient land for development. It is about finding a sustainable economic model that will enable the built heritage to be used purposefully, so that owners can afford to upkeep the heritage buildings. Inevitably, the debate on how much to conserve and where to conserve will continue and perhaps this is a healthy sign that people do care about heritage. On the whole, Singapore has developed one of the most comprehensive urban conservation programmes in South East Asia, having conserved some 7,000 buildings and structures, with many of the areas conserved as entire districts. In fact, in

2006, The Urban Land Institute recognised URA's conservation effort as one that 'balances free market economics with cultural conservation.'[21]

4) Reimagining the City from the Internet Up

During a recent visit to New York, I met up with Sidewalk Labs, Alphabet company's smart city incubator, that imagines, designs, tests, and builds urban innovations to help cities meet their challenges. Its stated goal is 'Reimagining cities from the Internet-up'.[22]

Singapore, too, has its Smart Nation ambitions, which is to 'support better living, stronger communities, and create more opportunities for all'. As a small integrated city state, Singapore is well poised to harness smart technology in a big way. It can help us to overcome our limited resources and make the leap to more innovative and effective urban solutions.[23] For a start, the intention is to focus on five key domains that will have significant impact on the citizen and society covering Transport, Home and the Environment, Business Productivity, Health and Aging and Government Services.[24]

The following are some of the more significant applications that hold promise in providing new possibilities for the physical management of cities.

4.1) Smarter Transport

With more than 1 million vehicles on the road and 4 million daily bus rides, smart technologies can help to optimise the use of our limited space for more efficient, safe, reliable and enhanced transportation. Some interesting ongoing initiatives include:

a) Mobility on Demand pilots such as the Delphi Automotive Systems and nuTonomy being piloted at the One North test bed. LTA will be introducing self-driving buses at Punggol,

[21] Singapore's conservation programme was awarded the Urban Land Institute (ULI)'s Award for Excellence: Asia Pacific in 2006. See https://www.ura.gov.sg.
[22] Source: https://www.sidewalklabs.com

[23] At the WEF 2016, UBS put together a ranking of countries most likely benefit the most from the next industrial revolution, based on a combined metric of the flexibility of their labour markets, how skilled their workers are, and how prepared the education system is for change and the legal system. Singapore was ranked second after Switzerland. (Source: uk.businessinsider.com, 4 Mar 2016)

[24] See www.smartnation.sg.

Tengah and Jurong Lake District over the next few years. Self-Driving Vehicles also hold great potential for freight transportation as they can address manpower challenges and ease traffic congestion during peak hours when they are deployed at night.

b) LTA has also analysed anonymised data from commuters' fare cards and identified commuter hotspots to manage bus fleets.[25] A next generation Electronic Road Pricing System slated for 2020 will collect real time data to provide a more accurate picture of real time traffic situation.

c) In anticipation of the use of more drones, Singapore has already introduced the Unmanned Aircraft Public Safety and Security Bill in 2016, which aims to regulate the use of drones with a clear set of rules. NTU is developing a traffic management system for drones. One-North has recently been designated as Singapore's first drone estate.

4.2) Home and Environment

Home and Environment smart initiatives focus on smart applications that improve liveability, sustainability and safety of the urban habitat and enable us to bring more reliable and efficient services to our residents. HDB has developed a HDB Town Smart Framework which focuses on harnessing digital technology. I will provide more details of these initiatives in my third lecture.

4.3) Health and Enabling Ageing

Assistive technology, analytics, robotics can be deployed for aging and healthcare. Such technology can help the shift towards home-based health care rather than institutionalised care, relieving the fiscal and manpower burden and the large land take required if we were to provide more new hospitals and nursing homes as the population ages.

From Digital-Age to En-Gage

While technical professionals and policy makers pursue the latest technological advances and the latest smart cool applications to better manage the city, we must remember that, ultimately, we are planning for our people. A more participatory approach to planning will enable us to better understand what they want and whether our plans are meeting their needs. A co-creation process

[25] Arrival times of buses are tracked using sensors installed in over 5,000 vehicles. With such information, there has been a 92 per cent reduction in the number of bus services with crowding issues and average waiting time on popular services have been shortened by 3 to 7 minutes. (Source: smartnation.sg).

can help to harness the ideas and enterprise of the community, and promote joint ownership of our environment.

Many of the proposed initiatives will not be successful without the support and co-operation of our people. For example, while transport experts can pronounce a 'car-lite' policy, car owners need to be persuaded to give up their car and to switch to alternative transport modes. As we introduce more cycling and PMDs, ultimately there needs to be more consideration between cyclists/ PMD users and pedestrians to harmoniously share the same pathways safely. Extensive engagement and education is needed to persuade citizens to adopt a common code of conduct.

Our attempt to build a low carbon and climate resilient society will fail without the participation of our people. Businesses need to be brought on board to embrace innovations and new business models in emerging concepts such as green growth (aligning climate mitigation and economic progress) or the circular economy (to keep resources in use for as long as possible in the manufacturing cycle). Green cities require 'green' citizens who have a 'sustainability ethos' ingrained in their daily lives. In Yokohama, their residents are able to recycle and sort out their trash into 15 types. Much needs to be done in Singapore to get more citizen buy in to better manage our personal use of energy, water and resources.

Strong Research and Innovation

Today, we are turning to research, innovation and technology as critical cornerstones to help develop appropriate urban solutions. The Singapore government has committed some $19 billion for the Research, Innovation and Enterprise (RIE) 2020 Plan from 2016 to 2020. Of this, some $900 million has been set aside for the Urban Solutions and Sustainability domain (covering energy, water, land and liveability). In 2017, MND has also launched a Cities of Tomorrow (CoT) R&D programme, setting aside $150 million to fund research and development towards building a more liveable, sustainable and resilient city for the future.[26]

There is also increasing recognition of the City as a series of Complex Urban Systems. This requires us to understand how each urban system and infrastructure system relates to the other

[26] The various areas of focus include advanced construction, resilient infrastructure, creation of new spaces and sustainable cities.

and the cause and effect between the different systems. This is necessary if we want a resilient city, and not risk a single point of failure.

However, the city is not just about efficiency, engineering and technology.

Towards a more humanistic approach to Urban Science

In a recent discussion I had with a group of eminent experts on how we should develop and manage cities, an important point made was that we must avoid a 'Hegemony of Infrastructure' in our approach to cities. Cities should not only be viewed as `machines' with a focus on efficiency and cost effectiveness through engineering/technology based infrastructure solutions. Technology should not be allowed to alienate people.

Cities must be developed with a view towards clear societal goals and outcomes, such as achieving a good quality of life, building communities and a sustainable environment to protect resources for future generations. Technology and infrastructure solutions are but enablers for our human-centred development goals.

Therefore, our research agenda should put people at its centre, and we should include behavioural sciences and social studies so that we understand the factors that could affect or drive human behaviour. For example, to guide the development of future transport plans, we need to better understand the factors that influence the choice of homes and work, which in turn may be linked to the choice of mode of transport. To plan for liveable density, we must ask what motivates and influences well-being—both spatial and non-spatial factors. What types of activities and what types of spaces are more likely to encourage better use and interaction? Beyond traditional data collection using surveys and census, we should shift towards harnessing big data which can be gathered through mobile phones, social media platforms and sensors on psychological, social and spatial behaviour to give us better insights.

We have generally been efficient over the years in applying many hardware solutions to deal with our urban challenges, but there is much more to be done to better understand the 'software' of cities. This is particularly important as society becomes more diverse. For this reason, stakeholder engagement has to become more mainstream in our development and planning processes. The success of many of our policies and urban solutions would depend on how well we can take into

account, nudge, and shape human and social behaviour and responses, so that we can build a better future together.

Dream Audaciously

Indeed, many mega trends are descending upon us that will affect our future urban environment. What is encouraging is that we have in place a process where we already take a long-term view. Coupled with a whole-of-government integrated approach and greater efforts to engage and work with our people, we are in a good position to prepare for future changes.

We are in an exciting time where, over the next few decades, several extensive development projects are lined up for development. To the west, there is the new commercial district at Jurong East with the new high speed rail station, and the Jurong Innovation District together with the new Tengah Town and the Tuas Mega Port. To the north, we will build up the Northern Innovation District together with the Woodlands Regional Centre and Punggol New Town. To the east, with the relocation of Paya Lebar airbase to Changi, we will have redevelopment opportunities. Changi Airport will further expand. To the south, the greater Southern Waterfront on vacated port land will see the expansion of Marina Bay to a new waterfront development along the southern coast. All these projects will give us many opportunities to test out new planning ideas, urban solutions and technology. With such great development opportunities, we should dare to dream and to dream audaciously.

> **A city isn't gauged by its length and width …**
> **but by the broadness of its vision, and the height of its dreams.**
>
> (Herb Caen)

With thoughtful people-centred planning, strong science and technology, and an innovative spirit, Singapore can continue to transform and shine as a `rock star' in urban solutions.

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