

## TECHNOLOGY AND THE CITY: FOUNDATION FOR A SMART NATION

Lacking land and natural resources, the Singapore government has consistently turned to information and communications technologies (ICT) and innovation to transform Singapore into a highly liveable city. Starting with early computerisation efforts in the 1960s, the government launched a succession of national ICT masterplans and e-government masterplans. These guided the use of ICT to enhance Singapore's international competitiveness, upgrade the workforce, attract knowledge-intensive activities, and improve public sector service standards. The application of ICT has also helped to shape the physical environment and development of the city-state, enhancing integrated planning and development in Singapore. Various ICT systems, data hubs and digital tools have been developed to support the work of the public sector in areas ranging from urban planning, land management, housing, transport, to municipal services. With the launch of the Smart Nation vision in 2014, many initiatives have been carried out by the public sector in collaboration with various stakeholders—the private sector, civil society and citizens. The digital revolution continues to influence the way we live, work, play and learn. This Urban Systems Study charts Singapore's experience in developing and leveraging ICT in its development journey over the past five decades.

*"Our Smart Nation initiative is actually not about technology. It is really about how we apply technology to enhance the quality of life for our citizens, to create greater opportunities for everyone to prosper and thrive in this new world where economic restructuring is occurring at an unprecedented pace and, to also strengthen community cohesion. In other words, it is about people, quality of life, opportunities and communities. Technology is only a means to an end."*

Dr Vivian Balakrishnan, Minister-in-Charge of the Smart Nation Initiative

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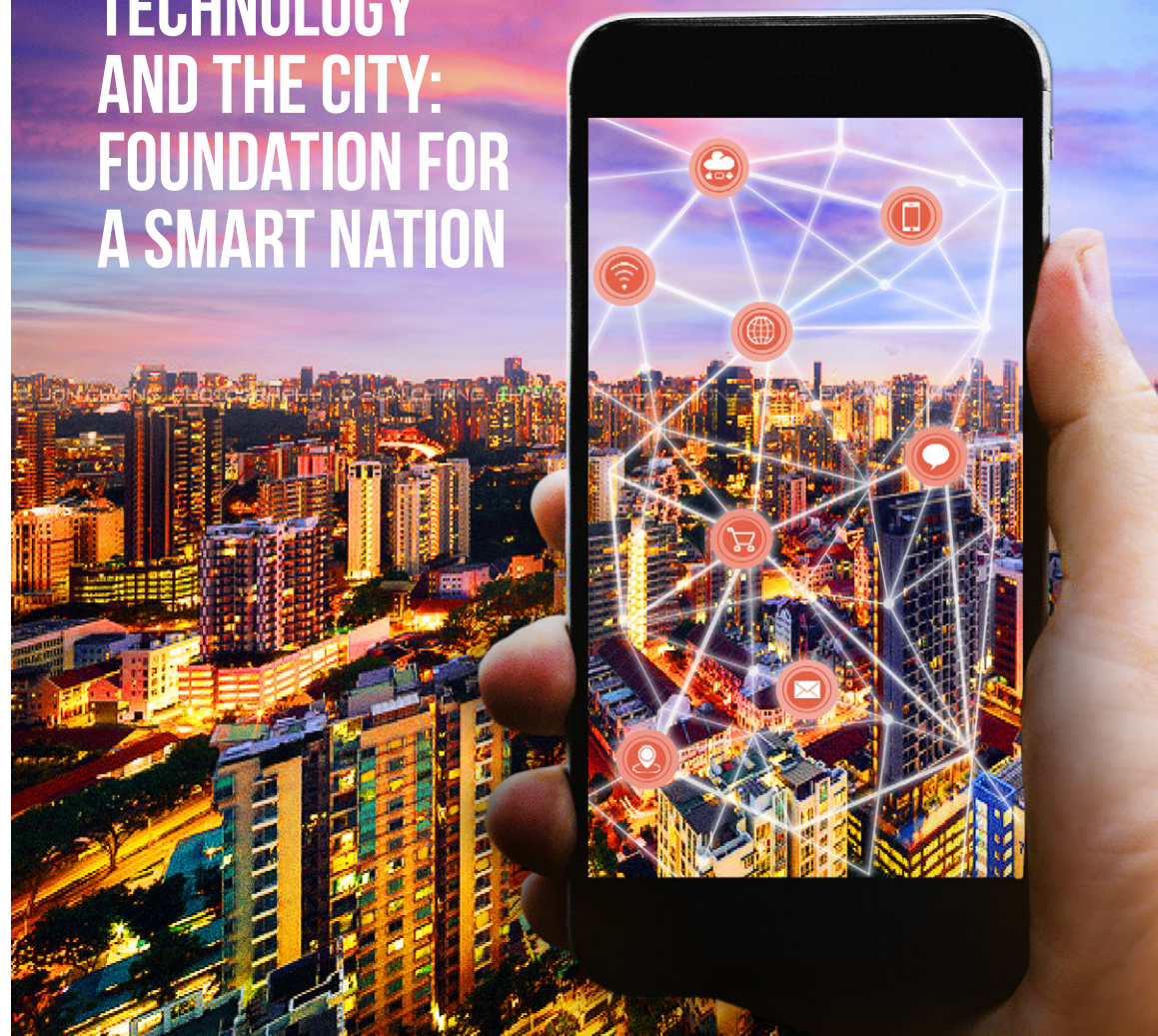
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TECHNOLOGY AND THE CITY: FOUNDATION FOR A SMART NATION

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# URBAN SYSTEMS STUDIES

## TECHNOLOGY AND THE CITY: FOUNDATION FOR A SMART NATION

CENTRE for  
**LiveableCities**  
SINGAPORE

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Cover photo:  
The transformation of Singapore’s information and communications technology landscape might not seem obvious to some, but their benefits are definitely tangible to many.

Image courtesy of Yu Lihui

# CONTENTS

Foreword	vii
Preface	ix
Acknowledgements	xi
The Singapore Liveability Framework	xii
<b>Overview</b>	
Introduction: Enabling Development through Digitisation	1
• ICT as a Key Enabler for Innovation	2
• Moving towards A Smart Nation	4
<b>Chapter 1</b>	
Riding the First Wave of Computerisation	5
• Computerising the Nation	6
– Computerising the Civil Service	9
– Promoting an Export-Oriented Software Industry	10
– Building a Local Core of IT Professionals	11
• Key Enabler to Rejuvenate the Economy	13
– Data Hubs for Land, People, Business	15
<i>Tradenet, Solidifying Singapore’s Position as a Global Trade Hub</i>	16
<b>Chapter 2</b>	
Unlocking Access to Greater Connectivity	19
• Transforming into an Intelligent Island	20
• Paving the Information Superhighway	21
– Start of a Nationwide Information Infrastructure	21
<i>Arrival of the Internet</i>	24
– Nationwide Broadband Network	26
– Next Generation National Infocomm Infrastructure	28
<i>Making Space for Future Infocomm Infrastructure</i>	30
• Planning for ICT in the Dotcom Era	32
– Forming the Infocomm Development Authority	32
– Evolving National ICT Masterplans	33
– Evolving Approach to e-Government	38
– Nurturing an IT-Literate Society	41
<b>Chapter 3</b>	
Harnessing Technology for Development	43
• Data-Driven Urban Planning	44
– First Nationwide Land Use Database	44
– First Nationwide Enterprise GIS System	47
– Land Use Planning in the Big Data Era	49

• Managing Land with Geospatial Data	53
– Consolidating and Sharing Land Data	53
– Collaborative Space for Geospatial Services	57
<i>Singapore's Digital Twin</i>	60
• Singapore's Heartland of Tomorrow	62
– Smart Planning	63
– Smart Estate and Environment	64
– Smart Living and Community	65
• Moving a City with Intelligent Transport Systems	67
– Streamlining Traffic Flows	67
– Monitoring and Sharing Information on Real-Time Traffic	68
– Managing Transport Demand and Revenue Collection	71
<b>Chapter 4</b> Dawn of the Smart Nation Vision	73
• Becoming the World's First Smart Nation	74
– Galvanising the Country for Smart Nation	77
– Developing Horizontal Enablers	78
• Seizing Opportunities in Smart Nation	82
– Reorganising the Regulatory Landscape	83
– Building a Hive of Digital Solutions	84
– Establishing a Common Sensor Infrastructure	87
– Harnessing the Power of Data	88
<i>Solving Municipal Issues as OneService</i>	90
• Turbo-Charging the Movement	94
– Struggles of a Fledgling Smart Nation	94
– Charting Out a New Approach	96
– Helping Citizens to be Digitally Ready	99
<b>Chapter 5</b> Staying Ahead of the Curve	101
• Challenges of Realising the Smart Nation Vision	103
Governance Tools and Timeline	106
Endnotes	116
Bibliography	123
Appendix A Evolution of the National IT Plans	129

## FOREWORD

In just over five decades, Singapore has transformed itself from an entrepot to a vibrant global hub and endearing home for people to live, work and play. To continue to build a competitive economy, improve our quality of life and maintain a sustainable environment amid the constraints of land and an ageing population, it is crucial that we innovate as a city and a nation. We have a tremendous opportunity in the digital revolution to overcome these limitations by using digital technology to improve lives, create economic opportunity, and build social bonds. The concept of a smart city is especially pertinent to Singapore and we have a slight advantage in this area. First, we are one of the most well-connected cities in the world, in terms of fixed broadband and mobile coverage. Second, we have a population with a very strong background in science and technology. Third, we have a society and leadership that are aligned both in terms of infrastructure and workforce to capitalise on technological advancements.

Singapore has long tapped technology advancements to move ahead. *Technology and the City: Foundation for a Smart Nation* tells the story of Singapore's journey from the time when computers were a rarity to today where smart mobile devices are considered a necessity in our daily lives. The decades of hard work by our pioneer leaders established a strong foundation for Singapore to build a sophisticated digital infrastructure that supports integrated planning and development.

The government then had the foresight and courage to prioritise the adoption of infocommunications (infocomm) technologies in various sectors and make substantial investments into the hardware. Singapore had a leadership that understood technology but did not use technology merely for its own sake. It had to bring about tangible improvements in the quality of life and create economic opportunities. More important were the efforts taken to change the mindset of the population to embrace IT. The principles that influenced the formation of the first National Computer Board in 1981 are still evident today in the ethos of the Smart Nation and Digital Government Office. Despite starting with a small pool of some 850 computer professionals, our IT workforce was ramped up through training and education. Today, the number of ICT professionals has increased dramatically, while a large proportion of Singaporeans are in the science and technology sectors.

The early investments paid off, and we have continued to build on that foundation. Our Smart Nation vision is far more than a smart city. Building a Smart Nation is a whole-of-nation effort that requires stakeholders in the public, private and people sectors to be firmly aligned towards the same vision. Digital technology plays a key role in the Smart Nation efforts, but the real determinant of success is how well a society adapts and prospers from technology changes and disruption. Our approach has always been to be as inclusive as possible, creating opportunities for our people and ensuring that no one gets left behind. Our national Silver Infocomm initiative which has been established for more than a decade, ensures that all Singaporeans can participate and benefit in the technology-driven transformation. More recently, we launched the Digital Readiness Blueprint which makes recommendations for interventions and programmes to include all Singaporeans and proposes how the public, private and people sectors can work better together for greater impact.

While we have made some progress towards developing Singapore into a Smart Nation, we must continue to raise our game in the years to come. The government will lead by example and accelerate our digitalisation transformation of the government's public service. The Digital Government Blueprint marks the commitment of the government to better leverage digital technologies to deliver citizen and enterprise-centric services that are both seamless and secure. Our public officers will also be able to continually upskill themselves, adapt to new challenges and work more effectively across agencies and with our citizens and businesses.

Like countries in the past that capitalised on the first industrial revolution to reap great power and economic wealth, Singapore is well-positioned to gain a head start by capitalising on the digital revolution. I hope that the lessons from Singapore's experience in planning and developing infocomm technology infrastructure and services, and our current endeavours to create a Smart Nation may guide future generations of policymakers and practitioners in Singapore and elsewhere. We are happy to share our journey.

**Dr Vivian Balakrishnan**  
Minister-In-Charge of the Smart Nation Initiative

## PREFACE

The Centre for Liveable Cities' (CLC) research in urban systems tries to unpack the systematic components that make up the city of Singapore, capturing knowledge not only within each of these systems, but also the threads that link these systems and how they make sense as a whole. The studies are scoped to venture deep into the key domain areas the CLC has identified under the CLC Liveability Framework, attempting to answer two key questions: how Singapore has transformed itself to a highly liveable city within the last four to five decades, and how Singapore can build on our urban development experience to create knowledge and urban solutions for current and future challenges relevant to Singapore and other cities through applied research. *Technology and the City: Foundation for a Smart Nation* is the latest publication from the Urban System Studies (USS) series.

The research process involves close and rigorous engagement of CLC researchers with our stakeholder agencies, and oral history interviews with Singapore's urban pioneers and leaders to gain insights into development processes and distil tacit knowledge that has been gleaned from planning and implementation, as well as the governance of Singapore. As a body of knowledge, the Urban Systems Studies, which cover aspects such as water, transport, housing, industrial infrastructure and sustainable environment, reveal not only the visible outcomes of Singapore's development, but the complex support structures of our urban achievements.

CLC would like to thank the Government Technology Agency, the Housing & Development Board, the Infocomm Media Development Authority of Singapore, the Land Transport Authority, the Municipal Services Office, the National Research Foundation Singapore, the Singapore Land Authority, the Smart Nation and Digital Government Office, the Urban Redevelopment Authority, and all those who have contributed their knowledge, expertise and time to make this publication possible. I wish you an enjoyable read.

**Khoo Teng Chye**  
Executive Director  
Centre for Liveable Cities

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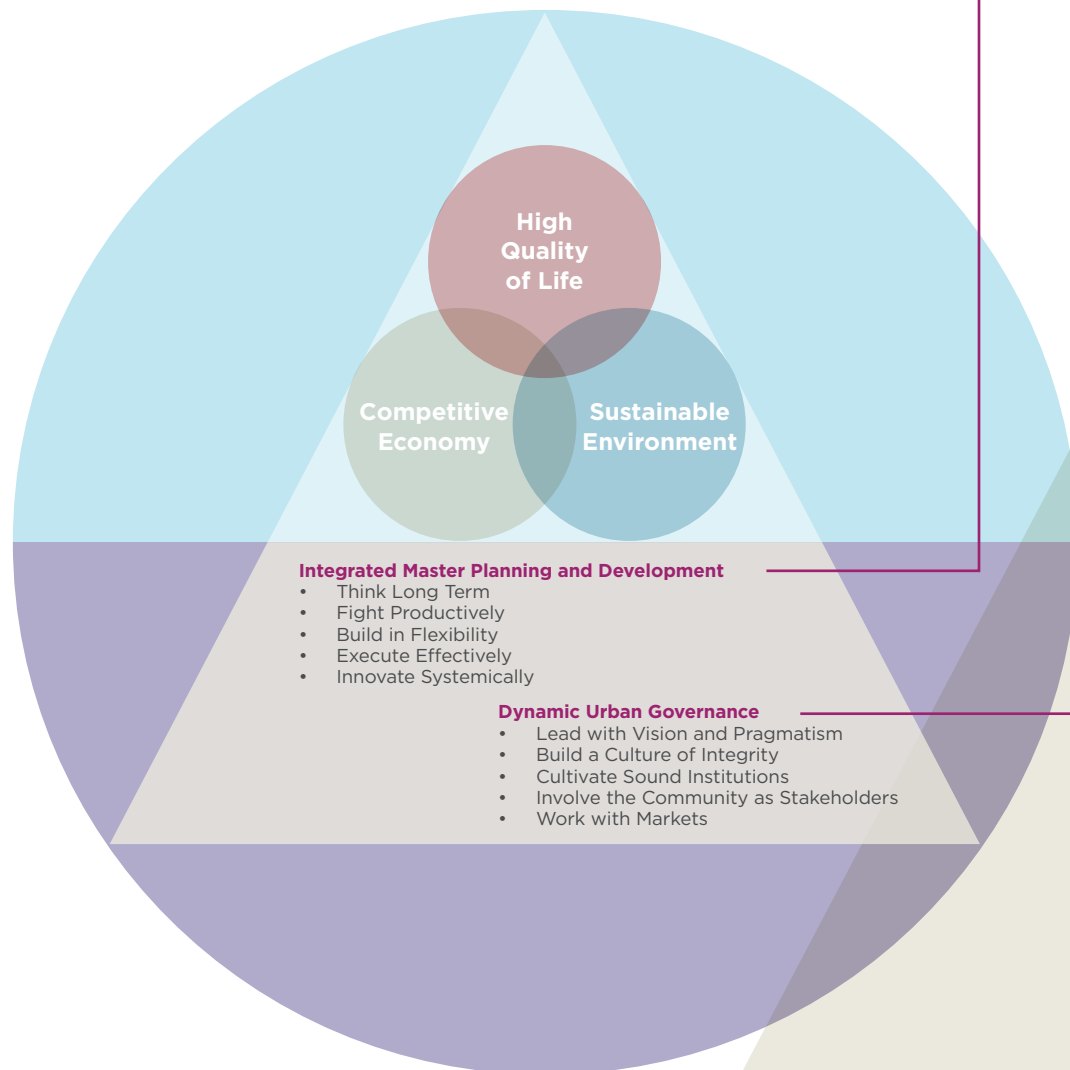
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# THE SINGAPORE LIVEABILITY FRAMEWORK

The Singapore Liveability Framework is derived from Singapore's urban development experience and is a useful guide for developing sustainable and liveable cities.

The general principles under **Integrated Master Planning and Development** and **Dynamic Urban Governance** are reflected in the themes found in *Technology and the City: Foundation for a Smart Nation*.



## Integrated Master Planning and Development

### Think Long Term

Since the 1980s, Singapore has been laying the groundwork for the island's information and communications technology (ICT) infrastructure to be future-ready by anticipating and preparing for long term trends. The government laid out masterplans progressively over the years which identified targets and capabilities required to achieve meaningful impacts to the nation through ICT and to align goals and expectations for all stakeholders. The government also readily invested ahead in physical and digital infrastructure that would serve as the "technical commons" for a wide spectrum of applications and services.

(see Nationwide Broadband Network, p. 26; Evolving National ICT Masterplans, p. 33)

### Build in Flexibility

Digital economic transformation has an exponential impact on the demands and needs of citizens. Therefore, the ability and willingness to rethink and remake currently functioning policies and frameworks is critical in order to stay relevant and to catalyse innovation. For example, the Government Digital Services unit which started as a small team at the Infocomm Development Authority (IDA), and later the Government Technology Agency (GovTech), retained its flexibility and responsiveness to deliver pilot projects within the public sector.

(see Building a Hive of Digital Solutions, p. 84)

## Dynamic Urban Governance

### Lead with Vision and Pragmatism

Smart Nation is a whole-of-nation effort that relies on political consolidation and committed leadership to lead, adapt and sustain the endeavour. The Smart Nation Programme Office (SNPO) was formed under the Prime Minister's Office (PMO) in 2014 to coordinate the efforts of government agencies, private companies, research institutes and citizens in delivering Smart Nation projects. To enable the government to be more integrated and responsive, the SNPO was restructured in 2017 with other policymaking and implementing agencies to form the Smart Nation and Digital Government Office (SNDGO) to oversee the overall Smart Nation initiative under the purview of a high-level ministerial committee.

(see Galvanising the Country for Smart Nation, p. 77)



### Involving the Community as Stakeholders

Citizens are key partners in Singapore's Smart Nation journey. It is thus imperative to engage and empower citizens in the city-state's development by providing opportunities and platforms for the public to adopt digital tools as well as provide feedback and ideas that could allow co-creation of solutions. Providing access to data through platforms like data.gov.sg also drive bottom-up innovations like the Bus Uncle and Haze@SG apps. Community bonds are also strengthened through crowdsourcing apps like MyResponder and OneService.

(see Harnessing the Power of Data, p. 88)

## OVERVIEW

### INTRODUCTION: ENABLING DEVELOPMENT THROUGH DIGITISATION



*Our vision is for Singapore to be a Smart Nation—A nation where people live meaningful and fulfilled lives, enabled seamlessly by technology, offering exciting opportunities for all. We should see it in our daily living where networks of sensors and smart devices enable us to live sustainably and comfortably. We should see it in our communities where technology will enable more people to connect to one another more easily and intensely. We should see it in our future where we can create possibilities for ourselves beyond what we imagined possible.”<sup>1</sup>*

Lee Hsien Loong, Prime Minister of Singapore

On 24 November 2014, Prime Minister Lee Hsien Loong unveiled Singapore's vision for a Smart Nation. The vision placed people at the centre of four enablers—governance, manpower, partnerships and technology. The launch of the Smart Nation initiative marked the latest milestone in Singapore's technology journey. In recent years, cities around the world have quickly recognised the benefits and opportunities that smart city initiatives could bring in addressing growing and more diverse urban populations in dense cities. While the term “smart city” was popularised only in the 2000s, the Singapore government has long tapped on information and communications technologies (ICT) for planning and service delivery, and this forms the foundation for the country's Smart Nation initiatives.

Faced with limited land area and few natural resources, the Singapore government has consistently turned to technology and innovation to optimise space and resource efficiency. Since Singapore's independence in 1965, ICT has played a vital role in the nation's transformation into a highly liveable global city. Singapore's ICT development started slowly in the 1960s and 1970s, as the adoption of ICT had to compete with other national priorities and the progress of mainframe computers was sluggish.

The subsequent rapid emergence and advancement of ICT pushed boundaries and opened up new opportunities. Today, ICT has become an integral part of life, shaping the way we live, work, play and learn, while the digital revolution continues to facilitate new collaboration models with businesses, communities and individuals.

## ICT AS A KEY ENABLER FOR INNOVATION

As one of the four Asian Tigers, Singapore's economy grew quickly during its initial industrialisation, and by the late 1970s, the economy went through a major restructuring from labour intensive to more high-technology and highly-skilled industries in the late 1970s and 1980s. There were new business sectors, especially services such as banking and financing, communications and tourism. These relied on ICT as a key enabler for their growth. Besides transforming the economy and enhancing Singapore's position as a global hub for business and finance, the Singapore government also saw the potential of using ICT to achieve better governance to make public service delivery more responsive and accountable, and improve the quality of life for citizens.

Since 1980, the government has launched six national information technology (IT) or ICT masterplans. In the formative years, the key focus was to computerise government agencies and drive up the quality and number of IT professionals in Singapore. Subsequent masterplans focused on extending computerisation and connectivity to the private sector, while also connecting its people to the broader world. While each masterplan had a different emphasis to address challenges of the period, the underlying objectives have been clear and consistent—to guide the use of ICT to enhance Singapore's international competitiveness, upgrade the skills of citizens especially the workforce, improve service standards, and attract knowledge-intensive activities. Within the public sector, many initiatives were rolled out to create the right policies, frameworks, institutions, and initiatives across different domains, in collaboration with the private sector and the public.

Through well-planned and coordinated efforts, the ICT infrastructure has been continuously improved to meet growing and changing needs of the society. It has resulted in marked efficiency gains within government agencies and a dramatic transformation of the economy. Supported by comprehensive ICT infrastructure, the city-state has been consistently ranked as one of the easiest places in the world to do business, and one of the most competitive and open economies for trade and investment. For citizens, ICT has proliferated in every aspect of the economy and society, from borrowing and returning of public library books, filing of tax returns, to dealing with municipal issues. As of 2017, Singapore has a mobile phone penetration rate of 150.8% of its total population, 94.5% of households have broadband access,<sup>2</sup> while more than 1,600 online government services and more than 300 mobile services are available for businesses and citizens.<sup>3</sup>



Since 1998, library services have been automated with the implementation of the Radio Frequency Identification (RFID) tags on each book across all national libraries.

Photo from the Ministry of Information and the Arts Collection, courtesy of National Archives of Singapore.

The application of ICT has also helped to shape the physical environment and development of the city. Various systems and tools have been developed to support urban planning and land management, housing, transport, municipal services, utilities management, construction and more. Singapore's development experience over the last half-century has also made the city-state a living laboratory for urban solutions.

## MOVING TOWARDS A SMART NATION

The rise of key technological trends, such as mobile platforms, social media, big data analytics, and the Internet of Things in the 2010s has opened completely new opportunities for countries, cities and citizens. At the same time, Singapore's challenges remain—a city-state with very limited land area, lacking in natural resources, a high-density urbanised environment, an ageing population, and constant competition from other global cities.

With the launch of the Smart Nation vision, a Smart Nation Programme Office was set up to drive and coordinate various efforts within the government and industry. By adopting the term “Smart Nation” rather than “smart city”, it sends a clear signal that a whole-of-nation effort is needed. Many initiatives have been carried out by the public sector in collaboration with various stakeholders—the private sector, civil society and citizens. Singapore often looks to new technologies to create innovative solutions to enhance its urban environment. With a well-educated population and the robust ICT infrastructure laid in past decades as a foundation, Singapore is “well placed to take advantage of the technology and make a quantum leap forward”.<sup>4</sup>

Yet technology alone is seldom enough to make a city more liveable. The crux is to apply technologies in an appropriate, systemic and coordinated way to meet the needs of the society and improve the lives of citizens. This book charts the milestones in Singapore's experience in developing and leveraging ICT in its development journey over the past five decades. It also looks at how Singapore has innovatively harnessed technology in its planning, development and governance to improve the lives of citizens and enhance its position as a global business hub.

## CHAPTER 1

# RIDING THE FIRST WAVE OF COMPUTERISATION



“I remember we put up a proposal to Dr Tony Tan to start up the NCB [National Computer Board]. We said we needed S\$100 million and he said ‘okay’ and put it up to Parliament. It was an act of faith. There was a sense of urgency to get things going.”<sup>5</sup>

Philip Yeo, Founder Chairman, National Computer Board (1981-87)

## COMPUTERISING THE NATION

In the 1960s and 1970s, computers were a rare sight in the public sector. The Central Provident Fund (CPF) Board was the first government agency to purchase a mainframe computer for batch processing in 1963.<sup>6</sup> Apart from the Ministry of Finance (MOF), no other ministry was allowed to set up its own computer department at the time. It was not until three years later when the Ministry of Defence (MINDEF) decided to introduce a computerised system for the allocation of national servicemen to technical vocations in order to manage manpower and logistics more effectively.<sup>7</sup> Despite initial attempts in introducing computers to improve efficiency, the civil service was slow to embrace the power of computing and lagged far behind the private sector, adopting outdated processes and computer systems that banks had used a decade earlier.

However, Singapore was fortunate that it had modern international communication links laid in the 1960s when the South East Asia Commonwealth (SEACOM) submarine cable system was launched in 1967.<sup>8</sup> Prior to this, high-frequency radio telephone circuits were used but they were unreliable and were subjected to interference. SEACOM greatly improved long-distance telephone and telex services and remained in use until 1986. At the same time, the government had decided to establish a satellite earth station in Sentosa (then known as Pulau Blakang Mati),

which was launched in 1971. This was followed by a second satellite earth station three years later. The development of such communications infrastructure helped to boost Singapore's standing as a manufacturing base and later as a regional and global business hub.



Then-Deputy Prime Minister Toh Chin Chye (second from the right) watching a demonstration at the inauguration of the computer service at the Treasury in 1964.

Photo from the Ministry of Information and the Arts Collection, courtesy of National Archives of Singapore.

The pace of computerisation in Singapore took a dramatic turn in the 1980s. By 1979, the government had recognised computerisation as an essential tool for competing against the rest of the world. A Committee for National Computerisation (CNC) was convened by then-Minister for Trade & Industry, Goh Chok Tong, with then-Senior Minister of State for Education, Dr Tony Tan appointed as its chairman in 1980.<sup>9</sup> The CNC formulated a National Computerisation Plan (NCP) that had a three-pronged approach in its strategy: computerise the civil service, encourage the private sector to do the same, and build up the talent pool in computing. The CNC also called for the creation of an agency to carry out the tasks and the National Computer Board (NCB) was therefore established under the MOF in September 1981 to oversee and coordinate all initiatives under the NCP.<sup>10</sup> Singapore was among the first countries in the world to establish a government agency to promote computerisation and IT industry development.

Dr Tan Chin Nam, who was then-director of MINDEF's Systems and Computer Organisation (SCO), joined the NCB as its first general manager in 1982 and later served as its chairman. Tan recalled how he and the founding NCB Chairman, Philip Yeo who was then a permanent secretary at MINDEF, were roped into the government's fledgling computerisation initiative:

*Tony Tan mobilised Philip Yeo as a committee member. I was in the MINDEF then and supported Philip Yeo in terms of the technical coordination, leading ten teams of officers from ten ministries, comprising computer professionals from the Computer Services Department as well as the Systems and Computer Organisation in MINDEF to come up with ten plans for the ten ministries. That became the Civil Service Computerisation Programme and it was injected into the National Computerisation Plan, along with a report of a visit where Philip Yeo led a team of six, including me, to visit IBM's training facilities...That led to the idea to form the National Computer Board and to form the Institute of Systems Science (ISS) in NUS [National University of Singapore] as an independent body to train systems analysts, convert non-graduates in IT to information systems professionals and provide computer appreciation courses to senior management and parliamentarians so that they would be supportive of this National Computerisation Plan.<sup>11</sup>*

The NCB had a strong technology advocate in Philip Yeo. To get around red tape of computer purchases during his time as MINDEF's director of logistics in the 1970s, Yeo had acquired MINDEF's first mainframe computer by classifying it as an "intermediate business machine".<sup>12</sup> He brought along his team of computer professionals from MINDEF's Computer Services Department (CSD) and SCO to the NCB. Yeo also gave credit to former Finance Minister Hon Sui Sen for the latter's foresight on the convergence of telecommunications and computerisation:

*We started building our infrastructure far ahead of everyone. Looking ahead at the merger, you know in 1981, when Hon Sui Sen was Finance Minister, he told me that we had to combine telecommunications and computers. He was far ahead of everybody else. That is why I brought Goh Seng Kim, [who] was then-head of TAS [Telecommunication Authority of Singapore] on the NCB Board and Tan Chin Nam from NCB sat on the TAS Board. The idea of bringing these two together started long ago. That was in 1981.<sup>13</sup>*

## Computerising the Civil Service

The first agenda in the NCP was an ambitious one—to computerise 10 ministries within five years. In the 1970s, only a handful of public sector organisations such as the CPF Board, the MOF and MINDEF used computers, and much time and resources were still devoted to keeping government records in physical folders. The SCO and the CSD worked with the MOF's Management Services Department and officers from the 10 ministries to formulate the Civil Service Computerisation Programme (CSCP) in 1981, which aimed to enhance public administration through the effective use of IT. The work done had become the foundation of the NCB.

Instead of parceling out IT contracts to the private sector to perform various jobs, the fledgling NCB took on the challenge of designing and building the computer systems for each of the 10 ministries on its own. A budget of S\$100 million dollars was allocated for this project and the fact that the NCB was established under the MOF gave it the clout needed to plan and implement computerisation projects for the entire public sector. Dr Tan Chin Nam explained, "The beginning of our national computerisation effort was very modest, but the vision was big. It was about preparing the whole country to become information savvy, information literate for our economic competitiveness and quality of life."<sup>14</sup>

One of the earliest challenges in this e-government effort was to convince public sector officers to embrace computers as productivity tools to boost operational efficiency and cut down unnecessary paperwork. However, once the agencies experienced the productivity gains offered by using computers, the demand for computerisation expanded exponentially.<sup>15</sup> According to former Deputy General Manager of the NCB, Pearleen Chan who helped to implement the computerisation programme, "[e]arly on, the government saw the need to enhance administration efficiency and realised that it could show its total commitment in taking the lead in computerisation. IT would also provide a solid base and strong impetus for the expansion of the local computer services industry."<sup>16</sup>



Participants at the third annual Civil Service Computerisation Programme seminar in 1986.

Photo from the Ministry of Information and the Arts Collection, courtesy of National Archives of Singapore.

The CSCP chalked up an impressive scorecard. By 1999, a total of 193 systems were developed, providing a return on investment of 171%.<sup>17</sup> It helped cut down 1,500 posts in the civil service and avoided the creation of 3,500 jobs.<sup>18</sup> Revenues for the local IT industry also crossed the S\$1 billion mark for the first time.<sup>19</sup> The programme, in effect, made the government the lead user of computer technology, creating more than 600 professional jobs in managing data centres.

### Promoting an Export-Oriented Software Industry

Another task of the NCB was to help promote the evolution of an export-oriented software industry. This was done primarily by coordinating with the Economic Development Board (EDB) to encourage leading IT vendors in the world to use Singapore as their regional marketing, technical support and software development hub in Asia. The EDB thus identified

the manufacturing of personal computers, printed circuit boards and disc drives as important sunrise industries and worked to attract companies in these areas. In 1981, Apple Computer started manufacturing personal computers in Singapore. This was followed by the entry of disc drive manufacturers including companies like Maxtor Corporation, Tandon Corporation and Seagate Technology.<sup>20</sup>

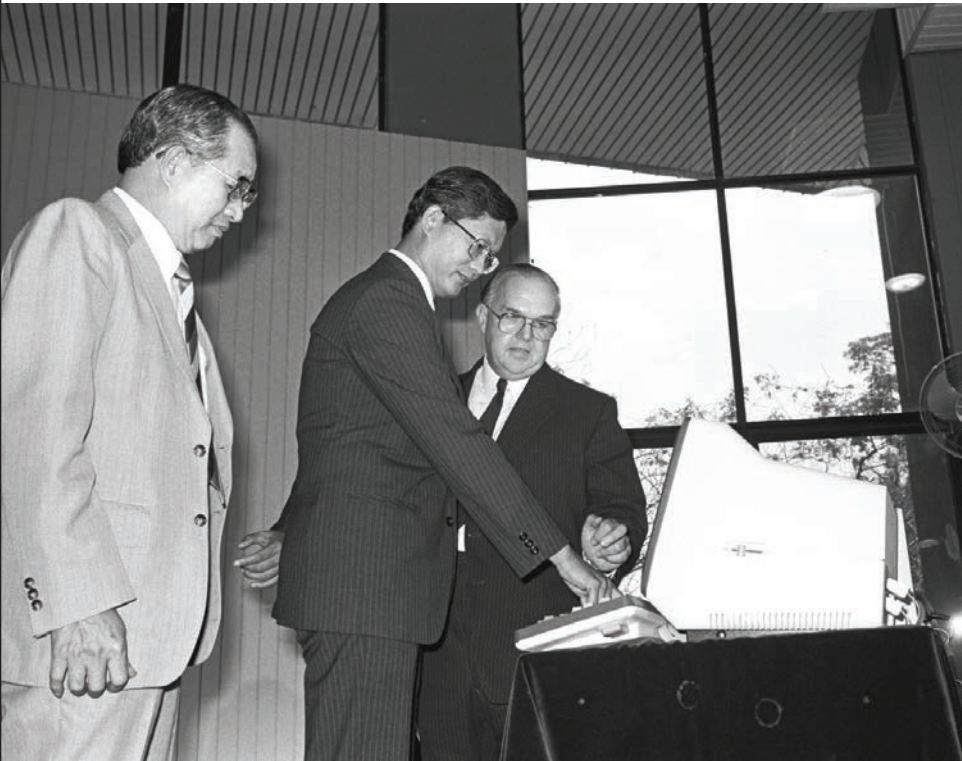
### Building a Local Core of IT Professionals

One of the greatest difficulties that the NCB faced was the shortage of manpower. When the NCP first started, Singapore only had about 850 computer professionals, many of whom were not trained specifically in computer studies.<sup>21</sup> In the formulation of the CSCP, the government recognised the need to ramp up IT manpower in Singapore in order to deliver the IT plans for 10 ministries. The vision was to have 5,800 to 7,800 IT professionals across various levels within 10 years.<sup>22</sup> The challenges were acknowledged by Lee Kwok Cheong who headed the CSCP in the early 1990s and later became the Chief Executive Officer of the corporatised National Computer Systems (NCS) under the NCB:

*We started with a small pool of somewhat experienced people and a larger number of inexperienced people. They had to convince users that there was a better way to run their business, came up with quality process and IT methodologies, and deliver ambitious computerisation projects all within a few short years. We could not outsource as the industry was also short in capacity and capability. What made a difference was the team was highly driven and passionate about changing the world using computers.<sup>23</sup>*

The local IT workforce had to be supplemented with overseas talent, and that was when the NCS was formed as a hiring vehicle for the NCB. As a separate commercial entity, the NCS had a greater flexibility in offering more attractive remuneration packages to recruit mid- and senior-level executives, as well as overseas computer professionals. To attract and retain promising IT professionals in the public sector, the NCB created career development opportunities in the areas of innovation, technology and application.





Dr Tay Eng Soon (centre), then-Minister of State for Education, at the opening ceremony of the Centre for Computer Studies in 1983.  
Photo from the Ministry of Information and the Arts Collection, courtesy of National Archives of Singapore.

The NCB also played a key role in the skills upgrading of the labour force to meet the specialised manpower needs of high-technology industries. A team of six from the NCB were sent to the United States to learn from the training facility at the International Business Machines (IBM). The ISS was later jointly set up with the IBM to train systems analysts, convert non-IT graduates into information systems professionals, and conduct senior executive programmes for the ministers, permanent secretaries and directors across the civil service to garner support for the NCP. As most of the earlier NCS recruits were non-IT professionals, they had to undergo systems analysis and design training at the ISS before they were dispatched to the various ministries to drive their computerisation efforts. These newly-minted information systems professionals formed the core manpower resource for the CSCP.

Subsequently, more institutions were set up to build local talent pool in information systems. These included the Centre for Computer Studies, a collaboration between Ngee Ann Polytechnic and International Computer Limited, as well as the Japan-Singapore Institute of Software Technology, which was later transferred to Singapore Polytechnic. In the same decade, more IT training collaborations like the Japan-Singapore Training Centre, German-Singapore Institute and French-Singapore Institute were also set up. All of these were part of the government's plan to build up manpower to develop Singapore into a regional centre for computer software development and services.

Within eight years, the NCB had fulfilled its mission to transform Singapore's IT landscape. IT manpower which stood at approximately 800 for the whole of Singapore in 1980, numbered over 33,000 by the end of 1998. The IT industry also grew from S\$69 million to over S\$12 billion over the same period.<sup>24</sup>

## KEY ENABLER TO REJUVENATE THE ECONOMY

In 1985, Singapore was hit by its first economic recession since its independence. At the time, computerisation of the internal operations of companies stopped short of facilitating business transactions with external entities. Hence, the Economic Committee—convened to restore the Singapore economy and chart future growth directions—identified IT to be a key enabler to improve trade competitiveness, rejuvenate key economic sectors and create the foundation for economic growth. Recommendations by the Committee led to the launch of the second National IT Plan (NITP) in 1986, which was incorporated as Chapter 17 of the Economic Committee's report. This step firmly embedded IT in Singapore's economic agenda and was a huge boost to the NCB's efforts in meeting the nation's growing demand for IT services.

The release of the NITP report was also the first time the term "information technology", comprising computer and communications, was officially introduced in Singapore. It also marked the year that the twin engines of growth—manufacturing and services—were identified, and the EDB was given the mandate to transform the economy sector by embracing both manufacturing and services sectors.

The spotlight shifted from computerising the public sector to extending the benefits of IT to the private sector. The NITP aimed to develop Singapore's IT industry into a world-class provider of IT products and services. Computerised applications were put in place in key economic sectors to facilitate the sharing of information across the public and private sectors. Unlike the first NCP, the NITP was more of a "bottom-up initiative involving various agencies coming together to articulate...the new version of the plan".<sup>25</sup> It was formulated with various agencies such as the TAS and the EDB. Dr Tan Chin Nam, who took over as the NCB Chairman in 1987, recalled his role in developing the NITP:

*[When] the NITP was formulated, we had a committee without a chairman. I did not describe my role as the chairman, so I would position myself as the co-ordinator just to rope in the very senior GM [general manager] of TAS who would delegate the responsibility to his assistant to come to add value in the committee, which would also have input from EDB. So, definitely it was an inter-agency committee...we presented the input to the Economic Committee Secretariat...[and it] was adopted by the Economic Committee as Chapter 17 of its report. So, that would give the empowerment to the National IT Plan.<sup>26</sup>*

To enhance Singapore's attractiveness and competitiveness as a trading hub, the Economic Committee also recommended that the NITP implement Electronic Data Interchange (EDI) platforms that would allow the sharing and processing of information between local and international companies. Singapore's first EDI platform was the award-winning TradeNet which simplified trade processing for importers, exporters, freight forwarders, cargo agents and shipping agencies. The turnaround time for trade permit approvals was reduced from about two days to just 15 minutes in 1989; it was later brought down to less than a minute.<sup>27</sup>

The NCB cast its net wide in implementing EDI platforms. Besides the TradeNet, other examples included PortNet, which enabled shipping lines, hauliers, freight forwarders, shippers and government agencies to communicate with the port and with each other; MediNet, a nationwide medical computer network linking the computer systems of all participants in the healthcare delivery system; LawNet, a legal information network that allows legal information services to be retrieved electronically; and BizNet, an information-sharing initiative that allowed quick remote access to information on businesses and companies.

## Data Hubs for Land, People, Business

Moving into the late 1980s, the CSCP began to look towards integrated systems that would facilitate sharing of information across departments and ministries. School Link, for example, connected the Ministry of Education to 360 schools island-wide, supporting teachers and principals in administration and facilitating communication between schools and ministry.<sup>28</sup> Others included the immigration system, which significantly reduced the screening time at the checkpoint; an automated card catalogue for the national library; a computerised registry of companies; and an automated national registration system for every newborn.

To facilitate information sharing across public agencies, the NCB centralised its servers into three very large data hubs in 1987. Each data hub carried large quantities of data from agencies related to one of the three—land, people, enterprises. Centralising the location of computers would also save on overheads and allow for better control over operations.<sup>29</sup> The different systems were linked via a government network called the IDNet to allow data sharing among government bodies. The hub of the network was a computer in the MOF.

The idea behind having a data centre was to have all required information in a "one-stop, non-stop" manner and encourage more agencies to share data. Chua Ah Leng, former Director of Government Systems at the NCB, elaborated on the rationale for this, "Why should the man-in-the-street only have access to the Civil Service between nine and five? 24-hour access can enhance the quality of life. Also, because the public will need to spend less time dealing with the Civil Service, it can use that time more valuably."<sup>30</sup> "One-stop, non-stop" was also part of the broader vision of the next national IT plan, whose scope would be manifold.

# TRADENET, SOLIDIFYING SINGAPORE'S POSITION AS A GLOBAL TRADE HUB

The idea of implementing an electronic network to facilitate approval of import-export documentation was mooted by the 1986 Economic Committee. Facilitating the clearance of goods through Singapore would enhance the nation's competitiveness as a trading hub. In the 1980s, the NCB had already developed a ship planning system—BoxNet which was later upgraded into PortNet—that helped the Port of Singapore Authority (PSA) to halve its planning time for each ship.

Having scouted the world to find the best technology, the NCB recommended the use of EDI as the core technology to support the message exchanges between the cargo and shipping agents and the relevant government authorities for clearance. A new company, Singapore Network Services (SNS), was set up to implement the system and launch the service.

TradeNet was launched in October 1989. The system allowed trade declaration documents submitted by traders to be automatically processed and routed to the relevant agencies for approval. Before the launch of TradeNet, customs declarations and



Queue at the Import and Export Office of the Trade Development Board in 1987, before the TradeNet was implemented.

Photo from the Ministry of Information and the Arts Collection, courtesy of National Archives of Singapore.

other trade-related documents had to be submitted in person to the relevant agencies and the approval of permits could take up to four days. TradeNet was also connected to two other networks—PortNet for ships and Cargo Community Network for cargo—which further facilitated shipping and air transport flows, and intermodal shipment of goods.



# TRADENET, SOLIDIFYING SINGAPORE'S POSITION AS A GLOBAL TRADE HUB

*Continued...*

TradeNet made an immediate and dramatic impact. The turnaround time for the processing of trade declaration documents was reduced to within 15 minutes. Costs were also reduced by 50% and productivity raised by 20%–30%.<sup>31</sup> By 1990, 90% of traders were on the TradeNet system and it became mandatory in 1991.<sup>32</sup>

Besides the leap in efficiency, TradeNet also radically changed the game for the trading community. Historically, government agencies were mandated to exercise control over imports and exports. Faced with a tight labour market and a government cap on manpower in the civil service, the Trade Development Board (TDB) decided to create a system which allowed traders to forgo the need for supporting documents. The onus was shifted onto the traders to comply with trade regulations and policies. Changing the mindsets of some 30 public sector organisations and 2,200 organisations from the trading and banking communities to participate in a single process and system using standard forms was not an easy feat, but it solidified Singapore's reputation as an efficient trading hub.

## CHAPTER 2

# UNLOCKING ACCESS TO GREATER CONNECTIVITY

“When IT2000 was launched in 1992, IT development was taken to a new level. It was not just computer and communication but also content. NITP was important because it gave an economic dimension to our national computerisation programme. When it evolved into IT2000, IT came to be seen as a way of life to enhance competitiveness and the quality of life.”<sup>33</sup>

Dr Tan Chin Nam, former Chairman, National Computer Board (1987–94)

## TRANSFORMING INTO AN INTELLIGENT ISLAND

In April 1992, the Singapore government announced a third national IT plan to extend the efforts of the 1986 National IT Plan (NITP) and to meet Singapore’s aspiration to become a world-class adopter of IT. Known as the IT2000 masterplan, the ten-year plan strived to transform Singapore into an “Intelligent Island” over the next 15 years, where rapidly advancing IT would be exploited to deliver higher quality of living and drive economic competitiveness.

The IT2000 plan was a huge effort involving some 60 senior managers at the National Computer Board (NCB) and 200 industry leaders, academics and senior government officers. Several working committees were also formed, covering 11 major economic sectors.<sup>34</sup> Former Planning Director at the NCB, Wong Seng Hon, recalled that “[t]he planning process was quite chaotic. It could be one person, with a personal idea, but it had to eventually embrace the whole group and then the whole country. The power of the plan comes from getting it accepted.”<sup>35</sup>

While the computerisation of work processes in the public sector was the focus of the previous national IT plans, IT in the 1990s was increasingly driven by the development of more advanced, ubiquitous information networks and digitalisation of content. In order to realise the vision of IT2000 for IT to be used by every individual in Singapore, an integrated and advanced National Information Infrastructure (NII) was needed to allow IT to permeate into every home, school and workplace. This era was also marked by the advent of the Internet as a new delivery channel that provided both information and transaction-based services to the public.

At around the same time, decentralisation was being introduced in the 1991 Concept Plan, Singapore’s strategic land use and transportation plan. Rather than being concentrated in the Central Area, commercial activities and employment were to be decentralised to regional, sub-regional and fringe centres as well as business parks and industrial parks, to provide more opportunities closer to home. The development of NII complemented the decentralisation strategy—as the island became more wired up, decentralisation became easier.<sup>36</sup>

## PAVING THE INFORMATION SUPERHIGHWAY

### Start of a Nationwide Information Infrastructure

With the plan for the NII, Singapore became one of the first countries in the world to develop a nationwide information network. A forerunner of today’s Next Generation Nationwide Broadband Network (Next Gen NBN), the NII was conceptualised as a key foundation piece for the IT2000 and a public service excellence initiative, “Public Service for the 21st Century” (PS21). Launched in 1995, the PS21 was a change movement to cultivate an anticipatory and change-resilient culture in the public sector in order to meet future challenges and seize opportunities.

The NII was to be a pervasive network interconnecting computers and other information equipment in homes, offices, schools and factories across the country, expediting the provision of common services and applications to the public. With the support of the industry and other government agencies, the NCB seeded various initiatives while developing the NII. These initiatives centred on putting in place the physical infrastructure as well as common services, such as electronic identification, national directory service and payment services, that in turn supported other applications and services.<sup>37</sup>

Compared to the initiatives of its earlier IT plans, the NCB's role as the master planner and chief architect of the NII turned out to be much more complex and difficult. The NII was an abstract idea in the IT2000 masterplan. Concrete specifications of the network technologies and applications were not laid out in the report because at that time, no country had yet developed an information network on a national scale and most of the IT applications envisioned in the plan had yet to be deployed on a commercial scale elsewhere. As a result, there was no funding earmarked for the NCB to develop the NII and funding for approved NII projects was only granted on a case-by-case basis.

The original idea of formulating a comprehensive implementation masterplan for the NII, including detailed technical specifications was later deemed to be too ambitious in the face of dynamic technological and market changes. The goal for the NII was gradually reduced to one focusing on the specification and design of generic "middlewares" that would run on top of the Internet for eventual commercial deployment. It was not until a proof-of-concept prototype was successfully completed in 1992 that the NCB began a series of demonstrations of potential applications to various government organisations, the IT industry, as well as academic and research institutions. The five applications demonstrated included telemedicine, a construction and real estate network, remote technical support, information services and concurrent engineering.

However, response to the demonstrated prototypes was mixed as some experts and researchers in the IT field felt that they were still far from being implementable due to scalability and technological issues. As a result, the NCB's attempts to seek additional funding from the IT sector and research and development (R&D) grants from the national research agency, the National Science and Technology Board (NSTB), to implement NII-related applications were largely unsuccessful.

It was only with the implementation of the Strategic Economic Plan, formulated in the early 1990s, that the NCB was able to tap on a S\$1 billion industry Cluster Development Fund established by the government in 1993. The fund was meant primarily for the Economic Development Board (EDB) to fund industry restructuring programmes and co-invest in new high-technology industries with multinational corporations and local companies. In September 1995, the government announced that a sum of S\$200 million from this fund would be allocated for an IT Industry Cluster Development Fund to fund IT2000-related projects.

Major changes were also taking place at the NCB at the time, including what another former NCB Chairman Lim Swee Say called "the biggest restructuring in NCB's 14-year history".<sup>38</sup> As a result, its role shifted from the implementation of national IT plans to providing strategic planning advice. The NII division within the NCB that was responsible for developing and implementing the NII was dissolved and reorganised into eight new clusters within the organisation. One of these was the Information Infrastructure Cluster, which monitored global NII developments and focused on developing common utility services that could be used in various applications.

As Singapore moved towards a highly-networked society, the implementation of NII projects required multi-agency collaboration. A high-level steering committee was formed to forge and implement the NII, charting the directions and development of information infrastructure, addressing policy issues such as data protection, information access, intellectual property and computer security. Non-technical issues such as policy and legal frameworks that took into account the business cost of implementing the NII were also drawn up and adopted.



# ARRIVAL OF THE INTERNET

The arrival of the Internet was undoubtedly a pivotal moment that kept Singapore on its march towards an “intelligent island”. It started with the decision of the National University of Singapore (NUS) to bring in the BITNET in January 1987, allowing staff to communicate on-line with colleagues overseas. Four years later, NUSNET was launched as a campus-wide computer network connected to international academic sites via certain sites serving as gateways between the BITNET and the Internet. It marked Singapore’s entry as a fully-fledged member of the international networking community and paved the way for Singapore to become a major Asian Internet node.<sup>39</sup>

The campus network caught the attention of the NSTB in 1991. The NSTB decided to work with the NUS to develop Technet, a nationwide computer network, to extend the benefits of the Internet to the R&D community outside of the NUS. By 1993, more and more organisations were requesting access to the Internet; and by 1994, some 50 organisations comprising R&D institutions, educational institutions, government bodies, and commercial organisations were connected. Although access was strictly limited to organisations with R&D interests, Technet was essentially Singapore’s first Internet Service Provider (ISP).



Official launch of NUSNET, a campus-wide network in NUS, on 11 April 1991.  
Photo courtesy of National University of Singapore.

The Internet made its debut to the public in 1994. The advent of the Internet coincided with the deregulation of Singapore’s telecommunications industry. SingNet, Singapore’s first commercial ISP which began operations in July 1994, was part of Singapore Telecom, the privatised entity of the Telecommunication Authority of Singapore (TAS). As demand for Internet access rose, the TAS decided to further open up the market to new ISPs and mobile phone service providers. Technet itself was acquired in 1995 by a consortium led by Sembawang Corp and became Pacific Internet (PacNet), Singapore’s second ISP.<sup>40</sup>

To provide all Singaporeans with a chance to access the Internet, Internet stations were set up at all national libraries, and cybernet cafes sprung up overnight.

## Nationwide Broadband Network

One of the key strategies of IT2000 was the development of an advanced, ubiquitous information network, the digitisation of content and the expansion of the multimedia content industries. This called for the development of the world's first nationwide high-speed broadband network, dubbed Singapore One Network for Everyone, or Singapore ONE. To enable this, the island-wide deployment of optical fibres undertaken by Singapore Telecoms was accelerated for completion by 2005.

This task had been made easier by the fact that some years back, building codes in Singapore had already imposed a requirement that all high-rise buildings had to be equipped with a Main Distribution Frame (MDF) room to house equipment that provided telecommunications services to the building's occupants. By December 1994, all MDF rooms in the Central Business District (CBD) and 75% of all public housing blocks were linked by an optical fibre network. By August 1995, it was estimated that some 158,000 km of optical fibres have been laid, covering 80% of all high-rise buildings in Singapore.<sup>41</sup>

Work on the Singapore ONE pilot network began in 1996. The Singapore ONE steering committee, comprised the TAS, the NCB, then-Singapore Broadcasting Authority (SBA), the NSTB and the EDB. The NCB drove the development of multimedia broadband applications and the deployment of information applications, while the TAS planned and supported the deployment of the physical broadband infrastructure. The NSTB facilitated broadband R&D for technology development. Finally, the EDB attracted overseas companies and investment, whilst the SBA encouraged broadcasters and other content providers to develop content for the broadband medium.

In June 1997, then-Prime Minister Goh Chok Tong officially launched the Singapore One pilot network, linking 300 homes to the service. The Internetwork Hub became the convergence point for all Internet service providers, commercial network service providers and government networks on the broadband network. Following the completion of the national optical fibre network, the network was launched commercially in June 1998, and subsequently rolled out at community clubs, libraries, and schools in the same year. The project received S\$200 million funding from the government, which went towards subsidising broadband subscription rates. In 1996, Tampines New Town with 200,000 residents in 52,000 households became the first housing estate in Singapore to be completely cabled. By 1997, Singapore ONE had 103 applications and 5,000 homes and businesses on board.

Linking up the island was however, only the first step. The Singapore ONE steering committee had a more ambitious plan. With broadband access in place, a vibrant market for content and services was expected to emerge and cater to business, recreational and educational needs. A development that excited the Internet community was the announcement that the cables would also carry data separately from cable TV channels. In a test on 18 April 1996, history was made in Singapore when a video-conferencing session was hosted between Tampines East Community Club and a public housing unit. Over the following week, high-speed Internet was also successfully tested over the cables, bringing the reality of an Intelligent Island much closer.

By 2000, the Singapore ONE network was accessible to more than 99% of Singapore, linking businesses, schools, tertiary institutions, public libraries and community centres on a high-speed information network.<sup>42</sup> The underlying ubiquitous ICT infrastructure, which included high-speed Internet access as well as wired and wireless networks, formed the “central nervous system” of the city.



Singapore ONE Partners showcase held at the National Computer Board at Science Park 1 in 1997.

Photo from the Ministry of Information and the Arts Collection, courtesy of National Archives of Singapore.

### Next Generation National Infocomm Infrastructure

The next step in the development of ICT infrastructure was the launch of the Wireless@SG programme in December 2006 to accelerate the take-up of high-speed wireless broadband among consumers and extend broadband access beyond homes, offices and schools, to public places. It formed part of the Intelligent Nation 2015 (iN2015) ten-year masterplan to develop Singapore's Next Generation National Infocomm Infrastructure (Next Gen NII), a new digital superhighway for connectivity.

Network coverage was progressively made available at public areas with high human traffic, such as the CBD, downtown shopping belts like Orchard Road, and town centres of housing estates. The number of Wi-Fi hotspots was bumped up from 900 in November 2006 to about 5,000 by September 2007.<sup>43</sup> By April 2012, there were about 7,500 Wireless@SG hotspots and 2.1 million subscribers to the service, with an average of 25.2 usage hours per month<sup>44</sup>, a significant rise from 6.7 hours per month in 2010.<sup>45</sup> To support the anticipated growth in demand for free public Wi-Fi services, the Infocomm Development Authority (IDA), the successor to the NCB, doubled the number of hotspots from 10,000 in 2015 to 20,000 in 2018.<sup>46</sup>



Singapore's free public Wi-Fi service, Wireless@SG is available in hospitals, government buildings and public areas such as community centres, hawker centres, train stations and retail malls.

Photo courtesy of Centre for Liveable Cities.

The Next Gen NII comprised a second component—Next Generation National Broadband Network (Next Gen NBN)—a wired broadband network that delivered ultra-high broadband speeds of one gigabit per second or more. As Singapore's most recent national infocomm infrastructure, the Next Gen NBN comprised three industry layers—a Network Company (NetCo), an Operating Company (OpCo) and various Retail Service Providers (RSPs).<sup>47</sup> The NetCo would be responsible for the design, building and operation of the passive infrastructure layer, while the active infrastructure would be the responsibility of the OpCo, which would deploy advanced technologies to support and enable a comprehensive range of ultra-high-speed wholesale broadband services to the downstream operators, the RSPs.

This industry structure provided a structural separation for the NetCo and operational separation for the OpCo to ensure that downstream operators had effective open access to the Next Gen NBN. The RSPs could obtain wholesale bandwidth services from the OpCo on a fair and non-discriminatory basis. This would in turn help create a vibrant and competitive Next Generation broadband market, giving businesses and consumers access to more choices and competitive pricing from a variety of RSPs. The government provided a grant of up to S\$750 million to the NetCo for the network rollout.<sup>48</sup> Jacqueline Poh, who was the Managing Director of the IDA and later the Chief Executive Officer (CEO) of the Government Technology Agency (GovTech), explained the rationale:

*The nationwide broadband network was an endeavour to bring fibre broadband to every household and every company in Singapore. We wanted to do it efficiently and at a low price for very high-speed fibre network. This should not be underestimated; I think too many people take this for granted today.*<sup>49</sup>

The NetCo, OpenNet (later renamed NetLink Trust), leveraged available underlying passive infrastructure assets such as ducts, manholes and exchanges line to deploy the optical fibre cables to residential and non-residential buildings, and even non-building points like lamp posts. This helped to minimise disruptions to the public. Despite delays in connecting some households and businesses, the ultra-fast broadband network reached over 95% of homes and businesses nationwide by 2013,<sup>50</sup> replacing traditional broadband services using cable and asymmetric digital subscriber line (ADSL) technology.



# MAKING SPACE FOR FUTURE INFOCOMM INFRASTRUCTURE

The Code of Practice for Info-communication Facilities in Buildings (COPIF) was introduced by the IDA in 2000 to ensure that developers and owners of buildings and developments provide adequate space and facilities for the deployment and operation of installation, plant and systems which are used for providing info-communication services to the buildings.<sup>51</sup>



Contractor of the NetLink Trust, the owner and operator of the Next Gen NBN, installing new surface trunking along the common corridor to house the optical fibre cable for open and equal fibre broadband access to all residential subscribers.

Photo courtesy of NetLink Trust, <http://netlinktrust.com>

Following the deployment of the Next Gen NBN, the IDA announced changes to the COPIF in April 2013 to “ensure that homes are built for future infocomm needs”<sup>52</sup> such as the adoption of digital and smart solutions for homes and offices and increasing pervasiveness of smartphones. The revised COPIF required an optical fibre termination point to be pre-installed in each new home, allowing homeowners to easily subscribe to fibre broadband services when they move into their new homes.

Another key change called for the provision of rent-free Mobile Deployment Space (MDS), where developers and owners of buildings and developments are required to provide space for the deployment of infrastructure for enhanced mobile coverage in both existing and new developments. The MDS requirements, which were on top of space requirements already specified in COPIF, would vary depending on the size of the developments, or the mobile coverage area. Mobile operators would in turn be expected to deploy more equipment to enhance coverage for the buildings and its surroundings. Developers and building owners only needed to provide the MDS upon request from the mobile operators and some flexibility may be accorded, such as allowing the MDS to be sited in varied locations like rooftops or car parks.

The COPIF 2013 also clarified the process and broad principles that the IDA would apply in allowing the use of a development's space and facilities to extend telecommunication services to areas beyond its boundaries. A key consideration would be whether the request for use is reasonable and whether the developer or owner concerned is made worse off.

## PLANNING FOR ICT IN THE DOTCOM ERA

The implementation of infrastructure like Singapore ONE and the Next Gen NBN was only one part of the equation in the development of ICT in Singapore. By the late 1990s, the global and national technology landscapes were undergoing significant changes. IT systems were rapidly being linked up through global telecommunication networks, ushering in what came to be known as the dotcom revolution. IT was giving way to the concept of ICT, referring to the family of IT and telecommunication technologies such as the Internet, email, e-commerce, broadband Internet access and web-enabled mobile devices and phones. Singapore's national plans had to evolve alongside these emerging trends.

### Forming the Infocomm Development Authority

When the NITP was launched in 1986, the scope of the government's involvement in IT promotion and policy broadened considerably. To foster more collaboration with other economic promotion agencies, the NCB was moved from the Ministry of Finance (MOF) to the Ministry of Trade and Industry (MTI) in April 1997. This move signalled an expansion of its role from an agent in computerising the civil service to a champion for developing the ICT sector into an economic pillar for Singapore.

Recognising the growing convergence between IT and telecommunications industries, a new agency was needed to navigate this technological convergence and to champion the growth of new industries and opportunities arising from it. In 1999, the NCB was shifted from the MTI to the Ministry of Communications & Information Technology (MCIT) to facilitate its merger with the TAS, forming the Infocomm Development Authority (IDA). The IDA remained under the MCIT until 2001 when it was transferred to an expanded Ministry of Information, Communications and The Arts (MICA), while MCIT was restructured to form the Ministry of Transport.

As the central agency responsible for planning, policymaking, regulation and industry development of IT and telecommunications sectors, the IDA played a few roles. First, the IDA was the National Chief Information Officer (CIO) to the government, and formulated national masterplans, policies and road maps for ICT. It advised the MOF, which at that time was the owner of e-government services, and it planned and managed infocomm services deployment within the public sector. The IDA was also the master planner of the NII to lead and direct a multi-agency effort to implement the infrastructure. It also spearheaded projects such as the PC (personal computers) Reuse Scheme and the Mobile Phone Reuse Project to build a more inclusive society. Lastly, the IDA played the role of an industry promoter by developing the ICT industry and manpower and facilitating ICT adoption and usage.

### Evolving National ICT Masterplans

#### Infocomm 21

Following its formation, the IDA's first priority was to develop a five-year strategic plan to direct the development of ICT to boost Singapore's competitiveness and improve the quality of life for citizens. Coinciding with the dotcom era, the Infocomm 21 blueprint was released in 2000 with the aim of transforming Singapore into an information society with a thriving e-economy and an infocomm-savvy society. Many services went online and companies ventured into e-commerce during this period.

In the early 2000s however, Singapore was being buffeted by an increasingly uncertain global economy, including a growing threat of terrorism marked by the September 11 attacks in the US, the rise of China and India, and the bursting of the dotcom bubble. Convened by the government in 2003, the Economic Review Committee formulated a new direction for Singapore as a globalised, entrepreneurial and diversified economy, and a leading global city.<sup>53</sup> Manufacturing and services would continue to serve as the twin engines of growth, albeit with a greater emphasis on knowledge- and research-intensive development. In conjunction with this new economic strategy, Infocomm 21 saw a new element of connectivity added to the "3Cs"—computing, conduit and content—of previous IT masterplans.<sup>54</sup> Another key initiative of Infocomm 21 was the implementation of the first e-Government Action Plan in 2000 to enable all public services to be delivered online.

The Infocomm 21 blueprint also supported the liberalisation of the telecommunications industry. This proved to be a pivotal milestone as it helped to hasten the development of telecommunications infrastructure in Singapore. Prior to this, the TAS was responsible for telecommunications regulations, network operation and services. By 1992, the commercial functions of the TAS were corporatised as Singapore Telecom (SingTel)



Then-Senior Minister of State for Transport and Information and the Arts, Khaw Boon Wan speaking at the Infocomm 21 Leadership Dialogue on 27 February 2002.

Photo from the Ministry of Information and the Arts Collection, courtesy of National Archives of Singapore.

The deregulation of the telecommunications industry also had implications on how infocomm systems for the public sector would be developed. The IT professionals of the NCB were reassigned to its corporatised arm, the National Computer Systems (NCS), which was transferred to SingTel in 1997 as a privatised commercial subsidiary. The IDA shifted towards an outsourcing approach of engaging third-party vendors to undertake software development work for government projects.

and Singapore Post, while the TAS retained its regulatory role.<sup>55</sup> SingTel held a monopoly on basic telecom services until 2000.<sup>56</sup> The results of telecommunications market liberalisation were impressive. By 2002, Singapore's telecommunications bandwidth had expanded by 400 times, and telecommunications costs had fallen substantially.<sup>57</sup> About 90% of government services were available online, while a third of Singaporeans were using broadband for Internet access from home, school or office.<sup>58</sup>

*[The government] adopted this outsourcing approach, and IDA became more like project managers working with the industry including computer professionals from NCB which were grouped under their legal employer NCS and became a subsidiary of SingTel...So, the outsourcing approach, continues to evolve. Now GovTech focuses on developing deep skills for our Smart Nation and Digital Government programmes as we transform Singapore into our future economy.<sup>59</sup>*

Dr Tan Chin Nam, former Permanent Secretary,  
Ministry of Information, Communications and the Arts

### Connected Singapore

Infocomm 21 soon evolved into a new Connected Singapore blueprint from 2003 to 2006. Put together by the IDA, Connected Singapore addressed the need to develop new sources of growth, in particular the creative industries of design and the arts. It was hoped that ICT could connect the power of computing, communications and content to create new business opportunities, consumer value and cultural experiences. The plan took on an inclusive approach, ensuring that everyone, the young, the old, and the less tech-savvy, would be prepared for the information age and the knowledge-based economy. The broadband capabilities of Singapore ONE was also extended to achieve pervasive wireless connectivity.<sup>60</sup> In the same year, the second e-Government Action Plan was implemented and the Creative Economy strategy—covering the arts and culture, design and media—was articulated.

### Intelligent Nation 2015

The rapid pace of change in infocomm gave rise to another high-level steering committee convened in 2005 to spearhead the development of Singapore's next ten-year ICT masterplan, dubbed the Intelligent Nation 2015 (iN2015). The iN2015 masterplan built on the vision of an "Intelligent Island" articulated in the IT2000 masterplan in 1992. Through a multi-agency effort led by the IDA, the iN2015 refocused on making Singapore strong in ICT infrastructure, enabling infocomm to be harnessed for innovation, integration and internationalisation. By providing a robust infocomm platform, iN2015 aimed to enable innovation among businesses and individuals and develop a globally competitive infocomm industry. As part of the iN2015 masterplan, the government built the Next Gen NBN, an ultra-high speed, pervasive and reliable infocomm infrastructure. During this period, the iGov2010 e-government action plan was also initiated to drive further integration across government agencies to better serve and connect with citizens.



## Exhibit 1

### National Infocomm Masterplans and e-Government Masterplans, 1980-2015

1980-85

#### National Computerisation Plan

Computerise the civil service, facilitate the development and growth of a local IT industry and develop a pool of IT manpower to meet the needs of the industry.

- Government computerised.
- Computer software and services industry grew 10-fold in revenue.
- IT manpower pool grew from 850 to 5,500.

1986-91

#### National IT Plan

Extend government systems to private sector through electronic data interchange networks.

- TradeNet, MediNet, LawNet successfully deployed.

1992-99

#### IT2000

Transform Singapore into an "intelligent island".

- Nationwide deployment of Singapore ONE.
- Policy framework for e-commerce (Electronic Transactions Act) put in place.
- Construction and Real Estate Network (CORENET) for construction industry, among other sectoral applications implemented.

2000-03

#### Infocomm 21

Establish infocomm as a key sector of growth, boost competitiveness of businesses and enhance quality of life through infocomm.

- Telecommunications market fully liberalised.
- Domestic and international infocomm connectivity increased.

1980-99

#### Civil Service Computerisation Programme

Raise public sector efficiency.

- Automation of public service.
- Development of basic IT infrastructure and data hubs.

2006-10

#### iGov2010

Whole-of-Government integration. Integration of data, processes and systems for government agencies.

- Integration of data, processes and systems for government agencies.
- 300 mobile government services deployed.

2006-15

#### Intelligent Nation

Enrich Singaporeans' lives, enhance the country's economic competitiveness and boost the growth of infocomm industry.

- ICT revenue reached S\$102 billion in 2012.
- 95% of homes and businesses wired up to Next Gen NBN.
- Wireless@SG programme launched.

2003-06

#### Connected Singapore

Enable individuals, organisations and businesses to become more efficient and productive, through infocomm; create and realise new possibilities by bringing together the power of computing, communications and content.

- Information harnessed in key sectors like logistics manufacturing, retail and education for further development of the sectors.

2000-06

#### e-Government Action Plan I & II

Public Service Excellence.

- Some 1,600 e-services deployed.
- Development of integrated services.

#### LEGEND

- National Masterplans
- e-Government Masterplans

Source: Info-communications Development Authority, Innovation, Integration, Internationalisation—Report by the iN2015 Steering Committee (Singapore: IDA, 2016), 33; "eGov Masterplans", GovTech Singapore, last modified 6 October 2016, <https://www.tech.gov.sg/About-Us/Corporate-Publications/eGov-Masterplan>; GovTech Singapore, "Speech By Dr Yaacob Ibrahim, Minister for Communications and Information, at the Infocomm Media Business Exchange Opening Ceremony", 18 June 2013, <https://www.imda.gov.sg/about/newsroom/archived/ida/speeches/2013/speech-by-dr-yaacob-ibrahim-minister-for-communications-and-information-at-the-infocomm-media-business-exchange-opening-ceremony>



## Evolving Approach to e-Government

While the national infocomm plans were directed at transforming the industry and society, the government infocomm plans, which were developed in tandem, set the key thrusts and strategies for transforming the government sector. From simple information publication, to interactive and fully transactional e-services, and finally public, private and people integrated e-services, the government's suite of digital services has been evolving.

Starting with the Civil Service Computerisation Programme in the early 1980s, which saw the civil service reap significant productivity gains, the NCB's activities and influence expanded significantly during the implementation of the NITP. IT applications in the public sector accelerated—between 1985 and 1990, the number of mainframe computers installed in government departments jumped from 35 to 107, the number of applications systems developed increased from 72 to 293, and the annual government computer spending increased from S\$14 million to S\$200 million.<sup>61</sup> Some of the public sector IT applications received international recognition, with TradeNet being one example. This laid the foundation for the launch of subsequent e-government masterplans.

### Electronic Government

In the early 1990s, the emphasis shifted towards the consolidation of computing systems in the form of a shared government data centre, a civil service-wide network infrastructure and a central infrastructure to allow agencies to share central systems and transmit data more securely and efficiently. The development of the first eCitizen portal in 1999 as part of PS21 movement marked another major milestone for e-government services in Singapore. Conceptualised to provide a first-stop and one-stop service for the citizens, the portal featured a wide array of public services, streamlined, redesigned and organised for the first time according to citizens' needs rather than by government agencies. It was expected to bring about "a significant difference in the way that Singaporeans carry out transactions with public sector organisations."<sup>62</sup>

The convergence of IT and telecommunications in the late 1990s paved the way for the launch of the Electronic Government Action Plan (2000–03) and the Electronic Government Action Plan II (2003–06). The key objective of the first action plan was to roll out as many public services

online as possible to three key stakeholders—citizens, companies and employees. E-services became widely used for services ranging from booking sports facilities to filing income tax returns and applying for a passport. Several significant e-government milestones were achieved during this period, including the eCitizen portal (gateway to different public services), SingPass (personal identification framework for e-services), BizFile (online business registration and information system), GeBiz (the government's online procurement system), EnterpriseOne (a portal that provides businesses with information and services from across the public service), and Careers@Gov (online job portal for the public service).

With several e-services in place, the emphasis of the Electronic Government Action Plan II was to improve the service experience of customers and develop the tools to help citizens connect with one another and the government.

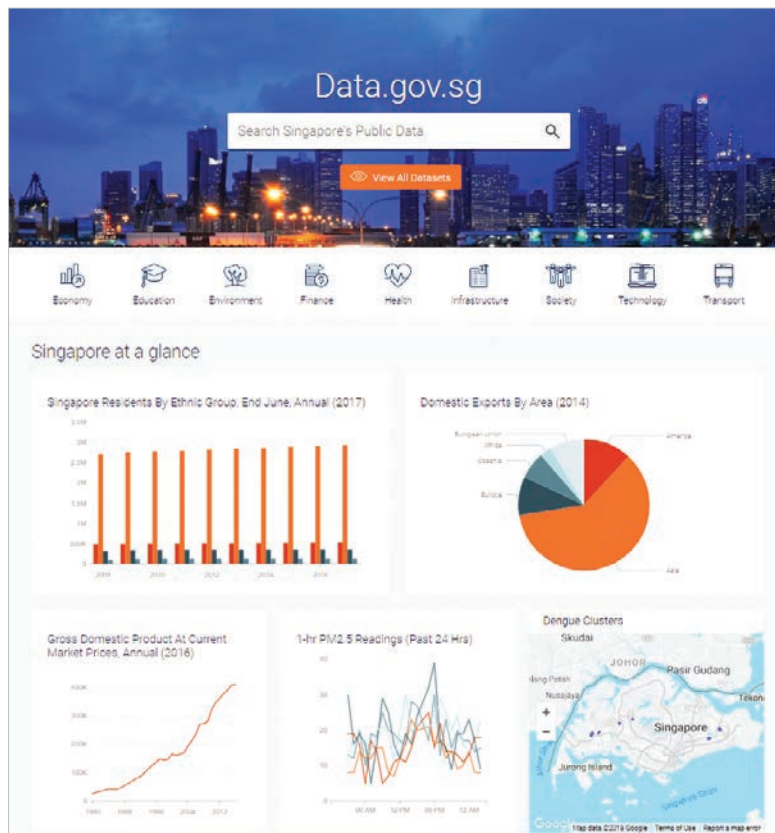
### Integrated Government

With the proliferation and increasing complexity of government online portals and the coming-of-age of digital natives who were proficient with using IT in their daily lives, ICT became an important strategic instrument to engage the public. Building on the achievements of the earlier e-government plans, the iGov2010 ("Integrated Government") masterplan from 2006 to 2010 was launched in May 2006. This masterplan emphasised a shift in focus across agencies from front-end to back-end integration, and from integrating services to integrating government itself.

The iGov2010 masterplan also formed an integral component of the broader national ICT masterplan, iN2015, where infocomm would help to create an environment conducive for flourishing businesses, a smart workforce and a well-connected society. One notable example of the initiatives launched under iGov2010 was Reaching Everyone for Active Citizenry @ Home (REACH). Set up in October 2006, REACH was a one-stop government engagement entity to lead in engaging and connecting with citizens to promote active citizenry. Another example was the Unique Entity Number (UEN) launched in January 2009, which provided a single identification number format to all entities registered in Singapore for their interactions with government agencies.<sup>63</sup>

### From Government-To-You to Government-with-You

The launch of eGov2015 masterplan (2011–15) in 2011 ushered in a new era of collaboration for the government, shifting from a “Government-To-You” to “Government-With-You” approach in the delivery of e-services. The scope for integration expanded from within the government to beyond it. The eGov2015 masterplan focused on three strategic areas—co-creating for greater value, connecting for active partnership, and catalysing whole-of-government transformation.<sup>64</sup>



Data.gov.sg was launched to make publicly available government data more accessible.

Image courtesy of Government Technology Agency of Singapore.

One key initiative was Data.gov.sg, a first-stop portal to make government data available to the public for purposes like research and application development. Other new ideas that were studied in the masterplan included cloud computing, business analytics, new media to enhance service delivery and enable new collaboration models among government, businesses and citizens. The advent of Web 2.0 and the widespread use of social networking tools during that period created an impetus and opportunities for the government to harness the resources, expertise and collective knowledge of individuals and communities.

### Nurturing an IT-literate Society

As Singapore advanced into the information age, efforts were made to guard against the potential threat of social segregation between the information-rich and information-poor. To realise the IT2000 vision of making IT an integral part of the lives of the citizens of the “Intelligent Island”, the government frequently demonstrated the advantages of an IT-enabled lifestyle to people of all ages and all walks of life to encourage citizens’ adoption of technology. Some key programmes that were launched included computer roadshows, IT Coach (an IT familiarisation programme), Singapore ONE clubs in community centres and the Hall of IT at the Singapore Science Centre.<sup>65</sup> By 1996, about 36% of households in Singapore owned a personal computer at home, a quarter of which had access to the Internet. In 1997, Singapore was ranked the second most IT-literate nation by the World Competitiveness Report.<sup>66</sup>

To further promote IT-fluency, the NCB and its partners conducted mass training events such as ONE Camp for students and parents, and Surf @ Stadium for businesses and members of the public in 1998. More than 15,000 people were trained to use Singapore ONE and Internet applications at these two events.<sup>67</sup> In collaboration with the National Library Board (NLB), the NCB also set up a one-stop training centre—ONE Learning Place—at the newly-renovated Toa Payoh Community Library in May 1999.<sup>68</sup>





Then-Minister for Education and Second Minister for Defence Rear Admiral Teo Chee Hean chatting with learners of Chinese at ONE Learning Place via the Internet during the launch of 1999 Speak Mandarin Campaign.

Photo from the Ministry of Information and the Arts Collection, courtesy of National Archives of Singapore.

The NCB also introduced other initiatives, such as a nationwide PC Reuse Scheme where used personal computers from government departments were donated to needy families and welfare organisations between 1998 and 1999.<sup>69</sup> The scheme was expanded to provide refurbished PCs bundled with free Internet access and basic IT training to low-income families. By 2001, 4,000 refurbished PCs had been deployed to needy families. Another 700 refurbished PCs were deployed to 63 non-profit organisations to set up IT resource centres to improve public access to ICT.<sup>70</sup> In 2001, the Mobile Phone Reuse project was also launched to provide the hearing-impaired with donated mobile phones, bundled with Short Message Service, to enable them to communicate easily with family and friends.<sup>71</sup> Such efforts helped to build familiarity with the use of ICT and encourage adoption, especially in earlier years when the technology was less widespread.

## CHAPTER 3

# HARNESSING TECHNOLOGY FOR DEVELOPMENT

Through successive coherent national information and communications technology (ICT) plans and e-government masterplans, the public sector often took the lead to adopt new technologies and introduce innovations that could raise service levels and offer better ways of engaging the citizenry. The application of ICT in various government agencies, from land use planning and land management, to public housing development and transport management, has also significantly shaped the physical environment and development of Singapore.

## DATA-DRIVEN URBAN PLANNING

In the city-state of Singapore, the limited land area and constant challenge of balancing competing land use demands for a growing population makes the need for a robust land use planning process even more crucial. Before the application of ICT, urban planning work was a largely manual process using tools like land surveys, paper records, and hand drawings. Hence, the data were often outdated and the tools were merely able to produce time-bound descriptive analysis and conceptual presentations, limiting the depth of planning analysis. The widespread adoption of ICT in the urban planning field, especially in the 1990s and 2000s, brought about major changes to how urban planning was done to better address increasingly complex urban issues in Singapore.

### First Nationwide Land Use Database

The launch of Singapore's first Concept Plan in 1971 ushered in an era of rapid and intensive development—from the renewal of the Central Area, and public housing development, to building of roads and rail system, industrial facilities and public utilities. By the 1980s, Singapore's national planning agency, the Urban Redevelopment Authority (URA), found that conventional manual processing and storage of data were becoming increasingly laborious and unwieldy, and worse, it was failing to keep up with the pace of planning and development work.

In 1980, a study team recommended the development of an Integrated Land Use System (ILUS) to serve three units of the Ministry of National Development—the Planning Department, the Roads & Transportation division of the Public Works Department (PWD) and the Building Control division of the PWD.<sup>72</sup> However, the initial stages of the project were hampered by the lack of appropriate technology at the time.<sup>73</sup>

It was only in 1989 that the proposal of developing a system using the latest ICT solutions, such as the Geographic Information System (GIS) to assist the work of land use planning, was mooted. As the Planning Department had merged with the URA in 1989, the ILUS project became led by the latter, supported by the technical expertise of the NCB. ILUS was the first-ever nationwide land use database IT system, making the URA a pioneer in the use of GIS at a time when physical paper plans were the norm.<sup>74</sup>

Implemented over a six-year period, the S\$36 million ILUS project comprised of two components—micrographic and computerisation.<sup>75</sup> Much work was done to convert the large volume of paper files, data and maps—accumulated over decades—into digital formats. Under the micrographic project alone, 15 million pages of historical files, and over 30,000 land use maps and plans, were converted into digital records and microfilm.<sup>76</sup> Peter Quek, the URA's first Chief Information Officer (CIO) detailed the initial difficulties of switching from a manual system to the ILUS:

*[There were] challenges because it was the early years of computerisation where information was mainly paper-based...so during ILUS, there was a major effort to digitise the data. We set up a dedicated data conversion team and major effort to convert large volume of hardcopy maps and paper forms into GIS format. This included data from URA, and then-PWD and BCD [Building Control Division]...That data still serve the needs very well today. The other transformation was for officers to adjust to new processes with GIS and hence training and change management was critical.<sup>77</sup>*

## Exhibit 2

### Concept of ILUS



Diagram courtesy of Urban Redevelopment Authority.

The ILUS system was commissioned in 1995, with key components to support the URA's work related to safeguarding of land, development applications and development guide plans. The system made it easier and faster for its planners to process information, evaluate planning proposals and applications, as well as prepare plans. It managed the vast amount of geospatial and textual data centrally, including information on site constraints and land use commitment, development applications

and case history, and planning decisions, which allowed for data search and entry to be done real-time. This minimised data redundancies and inconsistencies and improved work productivity for many departments within the URA.

At the same time, the URA spent much effort revamping its business processes and familiarising the staff with the new tool, so that they could take advantage of the system and the digitised data. Quek described the process as "quite a major change management...to get people to get used to changing from manual processes into computerised system, and using GIS system that was very new".<sup>78</sup>

In 2002, with the progress of GIS technology, the URA reviewed the requirements for the ILUS and subsequently decided to upgrade the system. The upgrade made the system accessible to a larger community of public sector officers and other users by deploying it on desktop computers and incorporating more user-friendly interfaces. The initial version of the ILUS was only available on shared workstations and required extensive training for users to be proficient in it.

### First Nationwide Enterprise GIS System

The upgrade extended the use of the ILUS system for another 5 years, before the rapid advancement of ICT and emergence of new circumstances and requirements in the planning work necessitated a comprehensive revamp of the platform. This culminated in a new planning support system, an enterprise-level Integrated Planning and Land Use System (iPLAN), launched in 2006. It was also the first nationwide enterprise GIS planning system in the world built on the platform of ESRI, a major GIS technology provider.

The iPLAN comprised many business modules to address the needs of different departments. These included Common GIS Module (which has basic functions used by most departments), Land Safeguarding Module, Development Control Module, Master Plan Module, Report Module, Data Publication Module, Access control and data security features that had been enhanced. During the implementation, the URA had to overcome several challenges, such as migrating from the ILUS system to the new system without major disruptions to day-to-day operations.



With iPLAN, staff from various parts of the URA were able to access common datasets including over 100 map layers, perform analysis, evaluate applications and generate plans more easily from their desktops. They were no longer limited to working on a specific site or an area, but could use the system at any level, including regionally or island-wide. Information retrieval on iPLAN was also more than 80% faster than ILUS.<sup>79</sup> In other words, the iPLAN enabled a much wider exchange of information and collaboration across the organisation.

The system also became a platform for the URA to generate and disseminate planning-related information to the public through its website and app, allowing the public to be better engaged in the planning process. One example was the 2008 Master Plan—a statutory land use plan that guided Singapore’s development in the medium term and was reviewed every 5 years—where the iPLAN was used to produce the draft masterplan in digital format and made it accessible for public consultation via the Internet.<sup>80</sup>



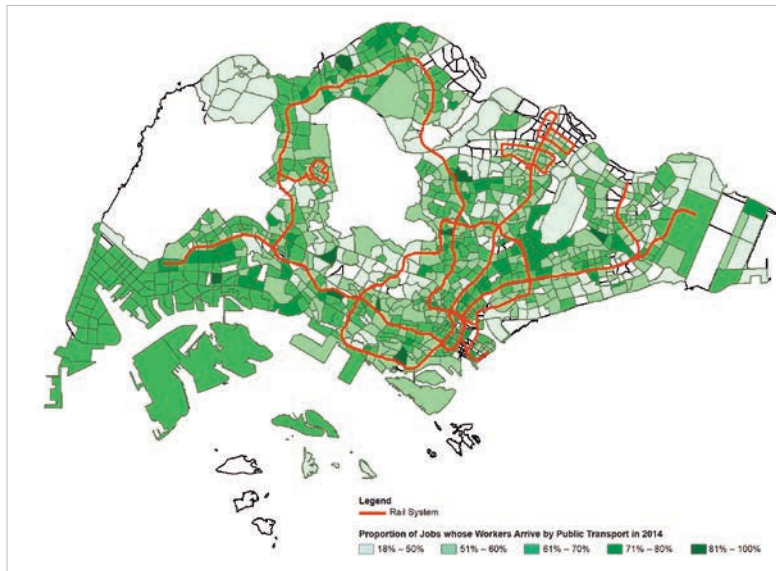
URA Master Plan published online.  
Image courtesy of Urban Redevelopment Authority.

## Land Use Planning in the Big Data Era

The ubiquity of mobile devices and the emergence of big data analytics in the 2010s opened new opportunities for urban planners to stitch together the vast data available across the urban sectors, thus gaining a better understanding of the needs of citizens for planning of services and amenities. To better exploit emerging digital technologies, the URA set up a Digital Planning Lab in 2013. With support from planning and development agencies, the private sector and research institutes, the URA went through a digitalisation journey to transform the planning process and developed a suite of digital tools for urban planning. Ng Lang, who was the URA’s Chief Executive Officer (CEO) from 2010 to 2017 and had led the agency’s digital transformation, explained the thinking:

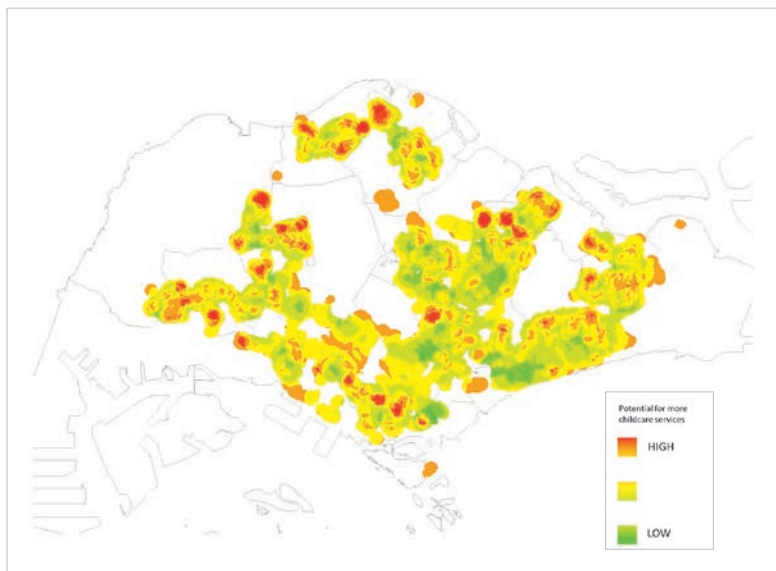
*At the core, the planning fundamentals have not changed. However, advancements in geospatial and data technologies have ushered in exciting possibilities to improve the way we plan. The new digital planning tools we are developing are helping to provide better insights in planning, coordinate our work better across agencies, and improve work productivity.<sup>81</sup>*

One example is the ePlanner, a one-stop geospatial planning analytic platform that provides access to and visualisation of over more than 120 datasets. Available on both desktop and mobile devices, the ePlanner allows planners to access and visualise many different types of data layers at their convenience, from population demographics and locations of amenities and facilities, to public feedback and traffic flows. The tool allows planners to discover new patterns and insights by overlaying and fusing various datasets onto a map. For example, the URA planners worked with the Land Transport Authority (LTA) to study travel mode patterns to work out how land use patterns affected travel demand and behaviour.<sup>82</sup> Additionally, to decide where childcare centres should be located, the URA and the Early Childhood Development Agency overlaid different layers of data to analyse the number of young children in all neighbourhoods and the capacity of childcare facilities in those areas.



Proportion of jobs whose workers arrive by public transport in an analysis done in 2014.

Image courtesy of Urban Redevelopment Authority.



Island-wide childcare gap analysis map done in early 2015.

Image courtesy of Urban Redevelopment Authority.

Peter Ho, Chairman of the URA, described ePlanner's significance to the Smart Nation as being a bottom-up initiative, rather than the result of a top-down direction.<sup>83</sup> Unlike the earlier GIS platforms implemented by the URA, the ePlanner was developed in-house by a multi-disciplinary team including urban planners and IT professionals. It was based on Web languages such as HTML5 and JavaScript, and various open-source mapping and data visualisation libraries. Getting access to the right data to develop digital planning tools was vital, but there were some challenges in convincing agencies to share data. Quek recalled:

*[W]e took a collaborative approach in data sharing with other agencies. Although there were some concerns on sharing of data initially, people started to see the benefits as we also shared data and the ePlanner tool with them. As more people use the tool and share data and use cases, the datasets become richer and the tool becomes more powerful—a network effect that benefits everyone.*<sup>84</sup>

The ePlanner also adopted a bottom-up approach by being easy to use—planners were able to use the tool after only a few hours of training—and the tool could be easily modified according to the users' business requirements, without the need for specialised IT skills. It has since been made available to some 30 public sector agencies, such as those in health, social and public safety sectors. Building in-house capabilities is therefore a critical step, as demonstrated in the URA's case, that has resulted in cost savings and better integrated systems.

To anticipate future infrastructure needs with changes in mobility and lifestyle patterns, other digital tools were developed. These included GEMMA—GIS-Enabled Mapping, Modelling & Analysis—which allowed planners to compose different planning scenarios, analyse different site choices and locations, and assess their impact from a local to island-wide level. Another tool was the URA's in-house three-dimensional (3D) Urban Model, which enabled planners and architects to visualise and assess the impact of ongoing and future projects on the city's skyline, environment and general aesthetics. The 3D models proved to be highly effective in conveying ideas, plans and strategies to other stakeholders in the development process. By demonstrating how a future project might look, the URA could gather instantaneous feedback from the public to guide the refinement of the plan.



Viewshed analysis using the URA's 3D Urban Model to analyse viewable area from an onlooker perspective at Jurong Gateway Area.

Image courtesy of Urban Redevelopment Authority.

In recent years, the data needed for robust urban planning were no longer limited to demographic shifts, land use demands, building controls, and distribution of amenities. The scope for planning had extended to emerging areas such as sustainability assessment, environmental simulation and behavioural analytics, which the URA and other relevant agencies have started developing. The so-called “wicked problems”—complex, large and intractable problems with no immediate or obvious solutions—in a rapidly changing city required faster processes, better integration of data, and seamless coordination across the public sector to build a holistic understanding of the city as an ecosystem. At the same time, there was a growing recognition within the URA that it had to plug into the larger ecosystem of other government agencies, private sector, research institutes and the community to better utilise emerging digital technologies.

*The current rapid advancement in disruptive technology offers exciting opportunities to explore new ways to plan, develop, and manage the city.*<sup>85</sup>

Ng Lang, CEO, URA (2010-17)

## MANAGING LAND WITH GEOSPATIAL DATA

Geospatial technology has played a significant role in Singapore's development journey, helping the government with evidence-based planning to optimise limited land space and resources. The practice of sharing geospatial information dates back to the 1980s, when the Civil Service Computerisation Programme (CSCP) saw the introduction of proprietary GIS systems within land-related government agencies. The lack of integration and disparate computerisation efforts of various agencies back then spurred the government to rethink how land data were shared. This led to the creation of the Land Data Hub (LDH), where data were treated as a corporate resource and shared across the civil service through a centralised data hub.

### Consolidating and Sharing Land Data

Established in 1989, the LDH was a central repository of land data from various government agencies, including the Land Office, URA, LTA, JTC Corporation, Building & Construction Authority (BCA) and Housing & Development Board (HDB). The implementation of the LDH was through the Land Systems Support Unit (LSSU) under the purview of the Ministry of Law (MinLaw).<sup>86</sup> With a centralised source of data, agencies could retrieve the most up-to-date geospatial data from the LDH for their operational and planning purposes. Much of the data in the LDH were in the form of cadastral maps, on which other information such as buildings, roads and utilities networks, could be superimposed.<sup>87</sup> Ng Siau Yong, Director of Geospatial and Data Division in the Singapore Land Authority (SLA) explained the rationale behind developing the LDH:

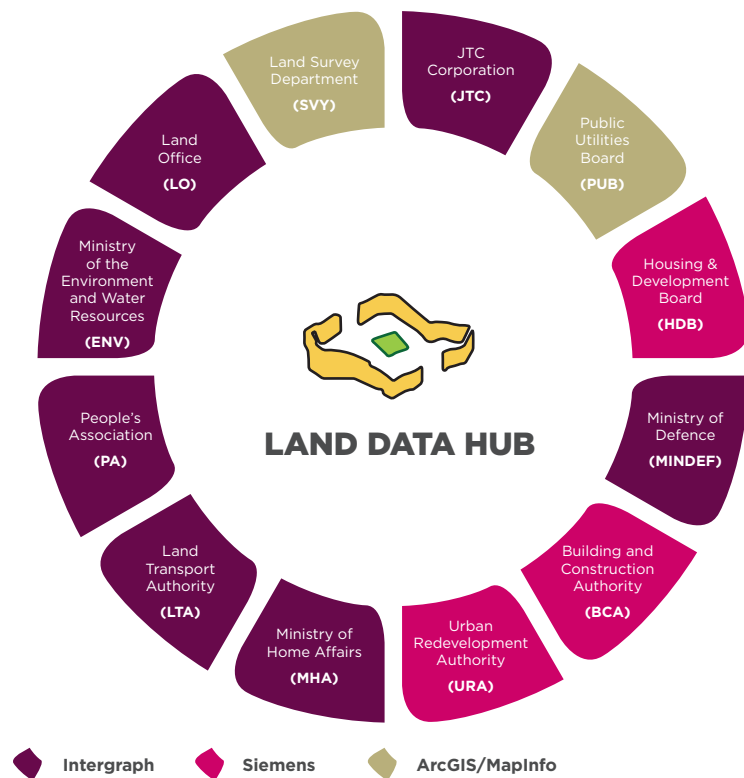
*...different agencies were adopting different kinds of geospatial data software, some used ESRI, some used Intergraph, some used Autodesk... So the Land Data Hub brings all these agencies together and acts as an intermediary to do exchange of data, and at the same time, helps to translate data from one format to another, to suit the needs of each agency.*<sup>88</sup>

The development of the LDH also enabled the standardisation and sharing of land data across government agencies, and reduced duplication of efforts in data creation and collection. From field survey, mapping, and conversion of data from paper to digital format, the laborious process of integrating different forms of map data into digitised map layers could take



many years.<sup>89</sup> To ensure that funding issues did not become a bottleneck in the project's progress, the LDH was centrally funded by the government with common map data sharing services provided to public agencies without charges, thus lowering the barriers to participation for the LDH.

### Exhibit 3 Concept of Land Data Hub



The private sector also benefitted from the LDH some years later. To facilitate the development of map-based commercial GIS services and products, the LSSU, which in 2001 became part of the SLA, released non-confidential digitised land data publicly through licensing their uses. This resulted in a range of map-based products and services developed by the private sector such as CD-ROM Street Directory, applications for vehicle fleet management, real estate property information services, handheld GIS applications and in-car navigation systems.

However, the method at that time of manually exchanging data via CD-ROMs and magnetic tapes on a quarterly basis was no longer adequate in fulfilling the growing demand for geospatial data from the various public agencies. The agencies also wanted greater flexibility in retrieving map data as the LDH required about three to five days for processing upon request.<sup>90</sup> The LSSU thus pilot-tested the concept and prototype of online sharing of geospatial data in 1998 under the name of LandNet with a few agencies. Primarily due to high development and maintenance cost, it was not expanded to include more participants.

In 2004, a new technology—Enterprise Grid technology—was introduced to the SLA. With it, online sharing through web portal became feasible and more cost-effective. The SLA was the first in Asia Pacific to harness the Enterprise Grid technology for geospatial data management and distribution. The technology allowed government agencies to access geospatial data through web portals without the need for setting up individual GIS infrastructures. It also allowed online data exchange capability to be scaled up incrementally and affordably by simply adding a new database server to the architecture when additional capacity was needed, thus lowering the barriers to participation and paving the way for the government-wide launch of the new LandNet.

In June 2007, the new LandNet was fully operational and provided the LDH with new capabilities, including online updates and map-based e-consultation. By connecting the networks of hardware platforms operating systems, data management systems and GIS environment into a single database, the new LandNet improved data integration and sharing through an online mode of data exchange. With the new LandNet, public agencies were able to access, view, upload and download spatial data—such as digitised information on Singapore's road and MRT networks, property boundaries, utility networks, outlines of public housing and industrial buildings—directly from the LDH at their convenience. The new LandNet had 16 contributing agencies and more than 220 layers of spatial data available for online access by all government agencies in 2010.<sup>91</sup> The provision of a common map and gateway to government services through the new LandNet was a vivid demonstration of the concept of “integrated government”.





LandNet provided users with the convenience of accessing data using a Web browser without the need for GIS software.

Image courtesy of Singapore Land Authority.

The new LandNet was running well up to the point when the SLA was confronted with yet again another financial hurdle. As a result of a new MOF directive to ensure greater accountability in the use of public funds, the SLA introduced a pay-for-use model on a flat fee basis in which participating agencies shared the costs of operating the new LandNet system. With the new cost-sharing model, the usage fell to less than half of the initial participation for the LDH. This prompted the SLA to introduce a pay-per-use model instead, in which heavy users paid higher fees overall and this proved to be more palatable to the agencies. It had been estimated that without the new LandNet, individual agencies would have spent more than S\$9 million in development costs and S\$2.5 million in annual maintenance costs.<sup>92</sup>

## Collaborative Space for Geospatial Services

*We realised that many countries are moving onto this NSDI [National Spatial Data Infrastructure]...So for Singapore, we already have a mini NSDI, in the form of Land Data Hub. We have the data, we have the platform in the form of LandNet. What we perhaps lack at that time was a comprehensive set of policies, standards and capabilities to govern and manage a central repository of geospatial information.<sup>93</sup>*

Ng Siau Yong, Director (Geospatial & Data), SLA

In April 2008, the SLA took the next step towards creating Singapore's National Spatial Data Infrastructure (NSDI) with the launch of the Singapore Geospatial Collaborative Environment (SG-SPACE). It represented a paradigm shift from sharing land data within the public sector, to creating an environment where the public, private and people sectors could collaborate on innovative applications and services using geospatial information. One of the SG-SPACE's objectives was to create linkages between the LDH and the other national data hubs for people, business and security respectively.<sup>94</sup> By coordinating the use of geospatial information across the public sector, this initiative would remove duplication in data collection, encourage reuse of data, and facilitate informed decision-making and monitoring of development.

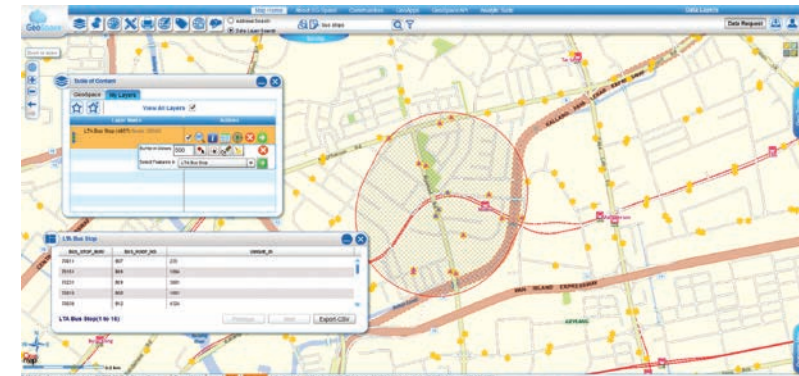
The successful implementation of SG-SPACE depended on a number of factors. The first and foremost was a strong public sector leadership—in the form of an inter-agency steering committee—that could get various agencies to work together. Secondly, the SLA established a whole-of-government data governance framework that provided clear data sharing protocols for agencies to share reliable and accurate information in a timely manner. A taskforce was also set up to match agencies' requests to the appropriate data sources. This ensured that the data content and structure were of high quality, interoperable across multiple agencies and conformed to international standards. To operationalise data sharing policies, the SLA implemented two centralised geospatial data platforms under the SG-SPACE initiative—GeoSpace and OneMap. Government geospatial data were shared within the public sector through GeoSpace, while those for the public were fed into OneMap.

OneMap, the first major product of SG-SPACE, was launched on 31 March 2010. By 2012, it had the participation of 81 agencies.<sup>95</sup> OneMap served as an integrated and interactive online geospatial platform where government spatial information and location-based services were shared with the public. It built on a common base map of Singapore and provided a myriad of services and functions that allowed users to search and navigate intelligently for places of interest such as museums, hawker centres, childcare services, parks and sports centres.

Public agencies, businesses and communities could tap on OneMap's advanced web mapping technologies to create new applications using government geospatial information. For instance, the SLA and the Ministry of Education co-developed SchoolQuery, which allowed parents of school-going children to locate primary schools within a certain proximity to their homes. OneMap presented close to 60 information themes and 34 map services and contributed to the launch of more than 20 applications, ranging from locating bird watching hotspots to volunteering opportunities and market profiling.<sup>96</sup>

Launched in April 2011, and replacing the new LandNet, GeoSpace was developed as a web-based portal hosted in the government intranet environment that integrated and published the government's geospatial data for better data sharing. More than 30 agencies contributed over 300 layers of data to GeoSpace, thus streamlining cross-agency processes and preventing duplication in data collection.<sup>97</sup> With GeoSpace, geospatial data sharing and usage increased significantly within the government. Compared to LandNet, the number of agencies accessing GeoSpace rose from 16 to 71, while the number of registered users grew from 300 to over 1,000.<sup>98</sup>

However, not everything was smooth sailing for GeoSpace. Historically, location-related datasets collected within the public sector were in formats that could not be readily shared. The government set aside a S\$15 million GeoFund to incentivise agencies to adopt geospatial information and technology in their work and to convert all spatial-related data into geospatial datasets.<sup>99</sup> For instance, the National Parks Board (NParks) developed a geospatial system for tree management. The initial funding model for GeoSpace was on a cost-sharing basis among the agencies involved, but this deterred some agencies from joining the platform. To encourage greater data sharing and access across the public sector, the MOF stepped in to fund central data sharing platforms, including GeoSpace, as shared government infrastructure. This decision resulted in much greater use of geospatial data in subsequent years.



GeoSpace showing buffer analysis tool.

Image courtesy of Singapore Land Authority.

At the same time, the SLA collaborated with other agencies, such as the URA and the IDA to plug the gap in know-how for geospatial technology within the public sector. A Central Geospatial Expert Service was housed in the SLA to guide agencies in developing geospatial solutions. One success was the National Library Board (NLB), which was able to optimise the locations of public libraries by combining information about accessibility, surrounding amenities and library sizes.<sup>100</sup>

To safeguard against data leakage and breach of confidentiality, the SLA implemented a policy to ensure that shared datasets in GeoSpace are categorised according to standard security classifications for government data and the agencies can customise and control access rights to their own data. As former SLA CEO Lam Joon Khoi explained, creating the right environment for data sharing was critical:

*I believe there is no short cut to overcome the impediments to sharing and we must persevere to create a mindset of sharing, and responsible usage. A transparent and collaborative environment is perhaps a good approach to begin.<sup>101</sup>*

# SINGAPORE'S DIGITAL TWIN

A 3D city model of Singapore has been built to allow urban planners to easily retrieve information on ambient temperature, solar irradiation or building height. Virtual Singapore—dubbed a digital twin of Singapore—is a dynamic 3D city model and collaborative data platform built on topographical as well as real-time, dynamic data. It will be the country's authoritative platform that can be used in simulations and virtual tests of new solutions to urban planning problems.<sup>102</sup> A project under the Smart Nation initiative, Virtual Singapore is a collaboration between the National Research Foundation Singapore, the Singapore Land Authority, and the Government Technology Agency of Singapore.

The SLA's national 3D map developed with the usage of digital imaging and Light Detection and Ranging (LiDAR) scanning technology in the air and on the roads is used as a base for the development of the 3D model in Virtual Singapore. Virtual Singapore integrates data from government agencies including road and infrastructure details, information from the Internet as well as real-time dynamic data from Internet of Things devices and sensors. Virtual Singapore comprises rich datasets including texture, material representation of geometrical

objects, and terrain attributes such as water bodies, vegetation, transportation and infrastructure. The geometry and components of a facility, such as walls, floors and ceilings are encoded into its building models. Such realistic and rich representation of physical Singapore will enable virtual experimentation, advanced analytical tasks and high-fidelity modelling and simulation that current geometrical 3D models are unable to support.<sup>103</sup>

Virtual Singapore will be able to simulate the potential and impacts of environmentally sustainable green features such as solar panels, green roofs, light-emitting diode (LED) lights, pneumatic waste conveyance system, enhanced pedestrian networks and extended cycling networks. Terrain attributes are also included as an accurate representation of the physical landscape and can be used to identify and show the most accessible, convenient and even sheltered pathways as well as barrier-free routes to aid the disabled and elderly. Communities could also leverage this modelling tool to co-create solutions and make collective decisions to improve their neighbourhoods, from choosing the colour of their building to identifying potential locations for community facilities.



Analysis of potential for solar energy production using Virtual Singapore. Image courtesy of National Research Foundation Singapore, Singapore Land Authority, Government Technology Agency of Singapore, and Dassault Systèmes.



## SINGAPORE'S HEARTLAND OF TOMORROW

With more than 80% of Singapore's population living in public housing flats developed by the HDB, housing is undoubtedly a key focus area in the Smart Nation agenda. Unveiled by the HDB in September 2014, the Smart HDB Town Framework mapped out the key strategies in introducing smart initiatives to HDB estates.<sup>104</sup> The framework consists of two layers. First, the enabling infrastructure, which is a horizontal layer that applies to all towns, and comprises the deployment of sensors, communication networks to transmit data, and a data hub to store and analyse data. The next layer is the applications and services, which is divided into five dimensions—Smart Planning, Smart Environment, Smart Estate, Smart Living and Smart Community. A multi-agency Smart Urban Habitat Steering Committee chaired by the HDB was also set up to formulate initiatives under the framework and identify new ideas that could be test-bedded in “smart living lab” sites at public housing precincts in Punggol and Yuhua.

### Exhibit 4 Smart HDB Town Framework

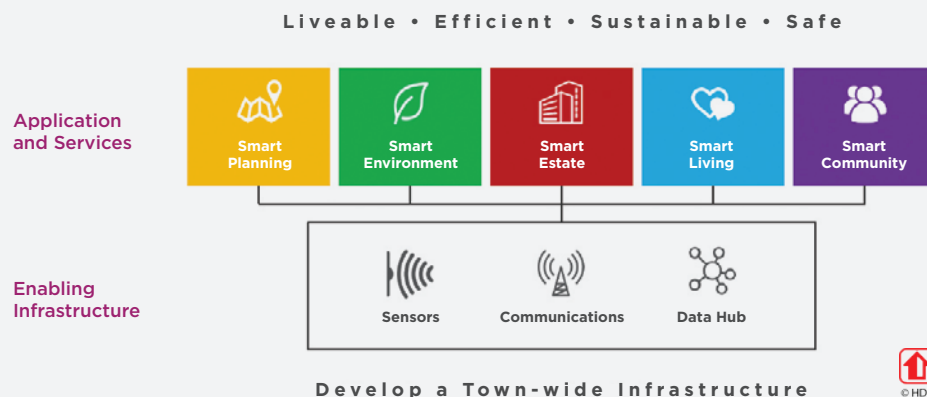
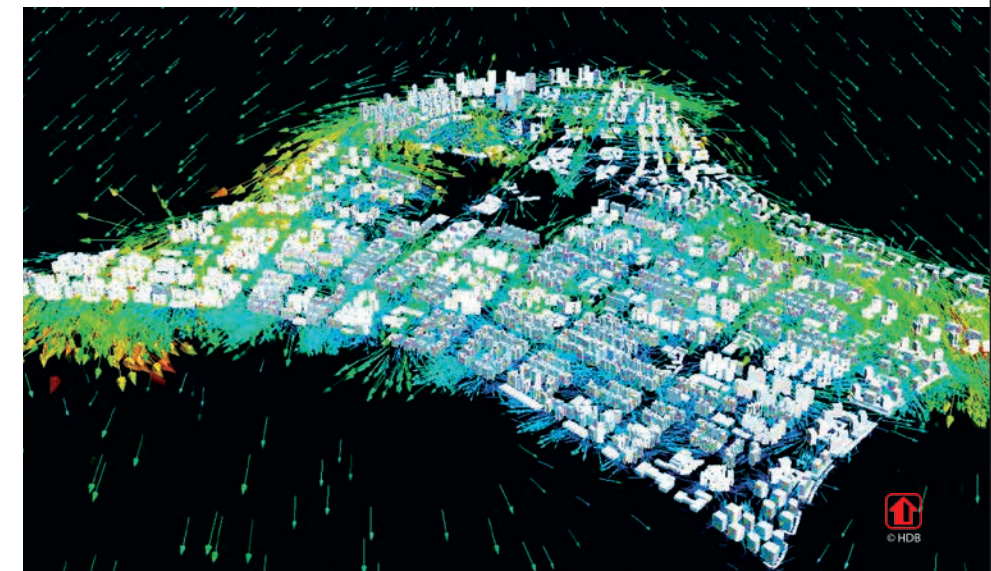


Image courtesy of Housing & Development Board.

## Smart Planning

Computer modelling and data analytics are used by HDB planners to test the town designs before developments are actually implemented. Onsite sensors collect real-time data which are integrated into simulation models to validate assumptions and assess the efficiency and cost-effectiveness of potential solutions. The HDB installs some sensors to monitor and measure the environmental performance of public housing estates, but it also taps on sensors deployed by other agencies under the nationwide Smart Nation Sensor Platform (SNSP).<sup>105</sup>



Environmental modelling is part of the Smart Planning process for Punggol, allowing HDB planners and architects to visualise the effect of design typologies on environmental conditions within the estate.

Image courtesy of Housing & Development Board.

The smart planning tools employed under the Smart HDB Town Framework include the Urban Environmental Modelling (UEM), which simulates environmental conditions, such as wind flow and solar irradiance, to determine the placement and orientation of new flats to optimise wind flow and minimise heat and glare. Treelodge@Punggol, the HDB's pioneer eco-precinct, was the first to benefit from the use of UEM. Its buildings were oriented to optimise natural ventilation. The UEM was also used in the planning of other housing precincts within the Punggol town.<sup>106</sup>



Another tool used by the HDB is the Complex Systems Modelling (CSM), a decision-making tool that simulates the impact of green initiatives introduced in towns and estates. It helps planners to assess more accurately the feasibility of introducing new features into HDB towns to achieve sustainability targets in a cost-effective way. For instance, the CSM was used to study the most effective way of placing rooftop solar panels, which in turn could influence the orientation and design of buildings. The CSM tool was first piloted in Yuhua and Punggol Northshore.<sup>107</sup>



A layer of sensors embedded in Punggol Northshore collects data to help develop better living solutions.

Photo courtesy of Housing & Development Board.

### Smart Estate and Environment

In collaboration with a private sector consortium, the HDB developed a whole-of-government data analytics hub known as the Smart Hub, which acts as the “brain” to manage and improve estate operations and services. It collects and integrates data from multiple sources into a central repository sited at the HDB. For instance, data analytics helps to identify usage patterns and predict potential maintenance issues, so that problems can be pre-empted and service disruptions avoided.<sup>108</sup> Other

government agencies that maintain public facilities like the national water agency, the PUB, the National Environment Agency (NEA) and the NParks can potentially also plug in their data to the Smart Hub.

Other Smart Estate features such as smart lighting help town planners to optimise the provision of lighting in common areas of the estate through data analytics, potentially reducing energy usage by as much as 40% in areas with little human traffic.<sup>109</sup> By monitoring real-time environmental data, such as temperature and humidity collected via sensors, public housing facilities can be more attuned to the needs of its residents. For example, smart fans located in common areas can be triggered only when needed, thus reducing overall energy consumption.

Another example would be the use of Pneumatic Waste Conveyance Systems (PWCS) that can help to improve the way waste is collected in towns, which also have implications on energy consumption. Some of these energy needs can be mitigated through placement of more solar panels, or through the use of Smart PWCS that activates suction based on the amount of waste detected in the blocks, instead of at fixed timings.

### Smart Living and Community

For households, the HDB is building digital infrastructure to pave the way for smart-enabled homes. Residents are able to use various smart home applications provided by commercial service providers that allow them to reap energy savings and access services like healthcare from the comfort of their homes. Unlike estate-level smart technologies which are standardised and controlled by the HDB to benefit from economies of scale, smart living depends on collaboration with the private sector to ensure that the designs of HDB flats are compatible with commercially-available smart solutions. Dr Johnny Wong, Group Director of the HDB’s Building and Research Institute (BRI) explained:

*...even if one [technology] proved to succeed today, it does not mean that there will not be any competition down the road insisting that their product is better...As such, for HDB, we are not looking at ‘inventing’ new smart home solutions. We are simply making our flats more conducive for such systems or solutions to be easily installed and used by our residents. We strongly encourage the private sector to be competitive and to really come up with new innovations to drive this further.<sup>110</sup>*

While smart technologies can be readily introduced by the HDB in common areas during the development phase, it is more challenging to implement smart home solutions. The Smart Elderly Monitoring and Alert System (SEMAS) in Yuhua estate—designed to replace an existing emergency call method—is one example that did not take off in a big way. While many found the solution useful, a majority of the elderly residents felt that they did not need such monitoring as they were still healthy. Only those who needed special care and attention at home found a real need to have SEMAS installed.

The HDB also leverages data analytics and ICT to better understand the evolving social composition within HDB estates and needs and preferences of residents. The advent of social media and mobile technologies has provided opportunities for new approaches to strengthen communities and allow residents to take greater ownership of their living environments. For instance, mobile applications are used to bring together residents with common interests through online communities, engendering a renewed “kampung spirit” (community spirit). Ideas for better public housing living can also be surfaced to the HDB through its “Cool Ideas” platform.

*More and more people are now connected through social media regardless of where they live. We can no longer define ‘neighbours’ by proximity and distance alone. Whilst promoting neighbourly ties by physical design remains important, we need to recognise the presence and power of online communities. By leveraging technology, virtual communities can nourish a sense of belonging and civic-mindedness, involving more people to shape and take greater ownership of the environment that they are living in.*<sup>111</sup>

Dr Cheong Koon Hean, CEO, HDB

Using a combination of data from traditional surveys, sensors and community engagement online and offline, the HDB can formulate more targeted policy and spatial solutions for HDB towns. For example, the HDB and the Singapore University of Technology and Design (SUTD) started an extensive research programme, the New Urban Kampung Research Programme, to better understand residents’ behaviour and preferences to guide the planning and design of HDB towns. By integrating urban analytics into environmental modelling tools, large amounts of social data can be analysed to run simulations of new initiatives before testing them in the physical environment.<sup>112</sup>

## MOVING A CITY WITH INTELLIGENT TRANSPORT SYSTEMS

Singapore has a long history of transport policy innovation, with technology playing a complementary role. Singapore became a pioneer in road pricing when it implemented an Area Licensing Scheme (ALS) in 1975, which imposed a fee on vehicles entering high-traffic areas in the city centre. The scheme was later extended to expressways under the Road Pricing Scheme (RPS). However, manual systems like the ALS that relied on enforcement by traffic wardens were labour-intensive and inefficient. With the emergence of transport technology in the 1980s, the government began to adopt Intelligent Transport Systems (ITS) to improve operational efficiency and road safety of Singapore’s road network.

### Streamlining Traffic Flows

One of Singapore’s earliest form of ITS was TRANSYT, an area-wide computerised and adaptive traffic signal system, introduced in 1981.<sup>113</sup> TRANSYT coordinated traffic signals within the city area by allowing pre-determined signal phases and timings to be changed in response to traffic demand at specific times of the day. This helped to relieve traffic congestion in the city areas, but as the urban population and transport demand grew, a more dynamic transport system was needed. The LTA deployed a series of ITS to link motorists, their vehicles and roadside infrastructures together, integrated under a single platform called “i.transport”.<sup>114</sup>

To manage traffic flow safely and efficiently for all users, Singapore has automated its traffic control systems to respond dynamically to changes in traffic demand. All traffic lights in Singapore today are linked under the Green Link Determining System (GLIDE) implemented in 1988 to replace the TRANSYT system. Modelled after the Sydney Coordinated Area Traffic system, GLIDE streamlines traffic flow by adjusting traffic signal timings based on real-time vehicle and pedestrian numbers. Vehicles are detected through wire sensors under the road at intersections, and by pushing buttons on traffic signal poles, pedestrians can alert the system that they need to cross the road. By 1996, the rollout of GLIDE was completed with 14 regional computers controlling all 1,370 signalised intersections in Singapore.<sup>115</sup>

The movement of public buses are managed by the LTA's Automatic Network Travel Time System (ANTTS) introduced in July 1995. Integrated with the GLIDE system, the ANTTS collects travel time information from tagged vehicles, mainly buses. The system identifies tagged vehicles coming within 50m of the detectors located at road intersections. The system then gives these tagged vehicles an extended green time, if needed, to clear the intersection. This has resulted in shorter bus journey times and improved reliability of bus services. Information on bus travel times along various roads can also be computed and disseminated to road users.

### Monitoring and Sharing Information on Real-time Traffic

Monitoring and enforcement systems have also been rolled out to ensure safe roads for all users and detect traffic violations. Operating around the clock, the ITS Centre in Singapore monitors traffic flow by collecting real-time information from various ITS on expressways and major roads. The information, ranging from incident sites to estimated travel times, is released publicly through platforms like radio broadcasts and websites like OneMotoring.com to help users plan their journeys.



The LTA's ITS Centre acts as a hub for traffic data collection and monitoring to enhance safety and efficiency of traffic operations and planning.

Photo courtesy of Land Transport Authority.



The Junction Electronic Eyes (J-Eyes) system—a network of more than 400 cameras—operates at major traffic junctions to monitor traffic conditions.

Photo courtesy of Land Transport Authority.

When the Central Expressway (CTE)—which included Singapore's first underground expressway section—was constructed in 1991, a traffic monitoring board was installed at the both ends of the underground tunnel to identify incidents and send alerts to incoming motorists. In early 1998, an automated version of this system, the Expressway Monitoring and Advisory System (EMAS), was introduced on Singapore's expressways and major roads. Along the CTE for example, the EMAS receives video images from 48 detection cameras placed at about 500 m intervals to monitor vehicle

speeds and detect traffic violations or congestion.<sup>116</sup> When any traffic accident or obstruction is detected, EMAS sends the message to the ITS Centre which then dispatches a recovery team to the accident site. Real-time updates on traffic conditions are also announced on electronic signboards placed along major expressways.

Today, the system covers some 150 km of expressways and major roads in Singapore.<sup>117</sup> EMAS has reaped about \$40 million per annum in time-savings due to shorter delays on expressways.<sup>118</sup> More than 320 major signalised intersections in Singapore are also equipped with advanced surveillance cameras—Junction Electronic Eyes (J-Eyes)—operated by the ITS Centre to detect traffic congestion and traffic violations such as illegal parking.





Parking Guidance System at Orchard Road, Singapore's shopping belt, displaying the number of lots available in the car parks within the vicinity. Photo courtesy of Centre for Liveable Cities.

Efficient sharing of real-time traffic information relies on an advanced information management system that collects, processes and shares such information across various platforms. The LTA implemented TrafficScan, which employs Global Positioning System (GPS) technology to collect real-time traffic information along major roads using sensors mounted on taxis. It also gathers traffic data from other sources like EMAS and J-Eyes to cross-validate the data.

The Parking Guidance System (PGS) receives data on availability of car park spaces from various car parks installed with parking guidance systems. The information is processed in a central computer and shown on electronic display panels located at car park entrances. The system helps to minimise circulating traffic, especially in high-traffic areas like the Central Business District (CBD), by directing drivers to areas where parking is available.

Implemented in 2008, PublicTransport@SG served as a one-stop portal for transport-related information, including an island-wide interactive map with integrated public transport information such as bus service routes, rail system maps, park and ride services and real-time bus arrival information.<sup>119</sup> Commuters could view bus arrival times via electronic signboards mounted at bus stops and interchanges, mobile phones and the Internet. On March 2010, an upgraded version of the portal, known as MyTransport.SG, was launched to consolidate the needs of various transport users—motorists, commuters, cyclists and pedestrians—into a single platform. It provides services such as bus arrival times, traffic camera views, parking guides and push notifications on real-time traffic news.<sup>120</sup>

### Managing Transport Demand and Revenue Collection

The efficient collection of road charges is another pillar of the ITS in Singapore. To automate the management of road congestion and collection of tolls, the earlier ALS and RPS were replaced with a nationwide Electronic Road Pricing (ERP) system in April 1998. The ERP system uses short-range radio communication to scan vehicles passing through ERP gantries at major expressways and arterial roads during peak hours and deducts congestion charges from smart cards inserted in in-vehicles units (IU) when the system is in operation.<sup>121</sup> Singapore became the first in the world to run such a sophisticated system at a nationwide level.

A massive exercise was conducted to fit nearly 700,000 vehicles in Singapore with IU in preparation for the system.<sup>122</sup> With the ERP system, rates could be varied for different roads and time periods to achieve the LTA's optimal speed ranges for arterial roads and expressways.<sup>123</sup> With IU installed in all Singapore-registered vehicles, the technology has also been exploited for electronic parking systems that automate payment of parking charges.

A next-generation ERP system using satellite navigation technology with island-wide coverage will be rolled out from 2020 onwards to replace the existing gantry-based system. The current IU will also be replaced with a new onboard unit with more functionalities, such as alerting drivers of priced roads and charges in advance, allowing drivers to better plan their routes or opt to take public transport instead.





Launched in 1998, Singapore's Electronic Road Pricing (ERP) system is the world's first nationwide automated toll-collection system used to control and manage road traffic volume.  
Photo courtesy of Land Transport Authority.

Moving forward, the nation will also be introducing other public transport initiatives designed to improve efficiency and convenience. Advancement in data analytics tools such as location-tracking sensors on vehicles and data mining of anonymised fare card transactions will better predict commuter behaviours and transport demand. Mobility patterns of individuals who walk or cycle to their destinations can also be analysed by leveraging mobile phone data from telecommunications companies.

## CHAPTER 4

# DAWN OF THE SMART NATION VISION

“Our Smart Nation initiative is actually not about technology. It is really about how we apply technology to enhance the quality of life for our citizens, to create greater opportunities for everyone to prosper and thrive in this new world where economic restructuring is occurring at an unprecedented pace and, to also strengthen community cohesion. In other words, it is about people, quality of life, opportunities and communities. Technology is only a means to an end.”<sup>124</sup>

Dr Vivian Balakrishnan, Minister-in-Charge of the Smart Nation Initiative

## BECOMING THE WORLD'S FIRST SMART NATION

Singapore has come a long way in building an intelligent nation. The 2000s saw the progress of many public agencies in harnessing the power of technology to improve their planning and operations. However, the digital efforts of public agencies were still disparate, diffused and patchy. As expressed by Prime Minister Lee Hsien Loong at the 2014 Smart Nation launch event, a common sentiment had emerged that Singapore could do better to take “full advantage of technology, particularly information

technology (IT) in order to be one of the outstanding cities in the world to live in”.<sup>125</sup> The effort had to be approached systematically, rather than piecemeal, to integrate different technologies together in a coherent and comprehensive way and create a common platform where everyone could contribute.<sup>126</sup>

The term “Smart Nation” was first coined by the Infocomm Development Authority (IDA) in early 2014. It was used in the IDA’s corporate vision to bring together three pillars in developing information and communications technology (ICT) within Singapore—Build (technology and enterprises), Govern (infrastructure and competition) and Deliver (a seamless experience for its citizens). Tan Kok Yam, who was at the forefront of the effort as the head of the Smart Nation Programme Office (SNPO), and subsequently as Deputy Secretary of Smart Nation and Digital Government Office (SNDGO), explained what a smart city might be in relation to Smart Nation:

*A smart city is one where the digital overlay, the use of data, machine intelligence and so on, just makes the city an excellent place to live in...because I can move data a certain way, I can automate certain processes, I can be more responsive as a digital government and city... With Smart Nation, there are two other components. One is the digital economy or livelihood component...it’s about how, as a country and society, the kind of digital products and services we can offer to the rest of the world? And how we can use the digital medium to reduce business cost, to reduce cost of transactions, to make the economy grow and thrive. The next component is digital society, which is how we can use the digital platforms to democratise public service, to allow people to contribute, to allow people to say, “I’m building something that is bigger than myself. I’m not [just] downloading.”<sup>127</sup>*

At that time, while digital government services were driven by the Digital Government Directorate at the Ministry of Finance (MOF), the infrastructure aspects of ICT development were led by the Ministry of Communications and Information (MCI) and the IDA. However, this division of responsibilities sometimes led to sub-optimal decision-making. There was a growing realisation within the government that “one needs to look at both infrastructure and services holistically”.<sup>128</sup>





Prime Minister Lee Hsien Loong at the Smart Nation launch on 24 November 2014.

Photo courtesy of Government Technology Agency of Singapore.

As cities around the world were totting out their own smart city agendas, Singapore—being a compact city-state—had some advantages in carving out its own strategic vision to become the world's first smart nation. Singapore's single level of government meant that the government could “decide efficiently, scale up successful experiments and pilots without any delay”, and “take a long-term view, and see through big transformations to the end, until they bear fruit for citizens”.<sup>129</sup>

The Smart Nation concept soon grew to become the vision for the nation. Officially launched in November 2014, the Smart Nation is a whole-of-nation movement that aims to harness the full potential of digital technologies to improve lives and empower citizens to achieve their aspirations, bring communities closer together, and encourage businesses to innovate and grow.<sup>130</sup> At the same time, three priority areas were identified.<sup>131</sup> First, it had to support Singapore's ageing population to age-in-place and lead fulfilling lives. Second, it was to develop breakthrough solutions in mobility in land-scarce Singapore, using technology and data to make transportation more efficient, public transport more responsive and improve the overall commuting experience. The third priority was to create more space for innovation, with the government releasing data to the public to build applications and services, and carving out testbeds for companies to easily test out new products and services.

## Galvanising the Country for Smart Nation

To set things in motion, a new programme office—the SNPO—was set up to coordinate the efforts of various government agencies that were already leveraging technology to serve citizens. Led by Minister-in-Charge Dr Vivian Balakrishnan, the SNPO was placed under the Prime Minister's Office (PMO) and was given the mandate to bring together all relevant parties from both public and private sectors to advance the Smart Nation vision.

The SNPO started with a lean team and three key roles. First, it was to galvanise public agencies to participate in digitalisation efforts and engage the public. Second, the SNPO would improve coordination across government agencies through the use of data and digital technologies. Last, it would develop standards and policies for information-sharing within the public sector. Transport, home and environment, business productivity, health and enabled ageing, and public services formed the five key domains of the Smart Nation initiative. Tan recalled how it started:

*SNPO was a 12-man outfit. At first it was one—that was me—and gradually more came on board. Because of our small size, we can't work with all agencies anyway. So, we started by first working with a few to demonstrate that if we are ambitious, if we work together systemically, we are able to deliver something better.<sup>132</sup>*

The SNPO began by facilitating a whole series of schemes and pilot tests by agencies. These ranged from the Smart Elderly Monitoring and Alert System (SEMAS) which enabled caregivers to watch over the elderly living alone, to Virtual Singapore, which used crowdsourced data to help planners and architects to plan and design the city using rich 3D details. The government also convened a high-level Committee for Autonomous Road Transport for Singapore (CARTS) to explore how autonomous vehicles could be used for moving goods as well as people. Trials for self-driving cars began at one-north in 2015 and have garnered participation from private organisations. Efforts to develop self-driving buses are underway as well.





The Centre of Excellence for Testing and Research of Autonomous Vehicles at the Nanyang Technological University (CETRAN) test centre paves the way for self-driving vehicles to be deployed on public roads by providing a safe and controlled environment for rigorous testing.

Photo courtesy of JTC Corporation.

At the same time, the IDA continued its efforts to build pervasive and resilient connectivity for Singapore to serve as the foundation on which new technology innovations could be built. Much work had been done in earlier years, such as the roll-out of the Next Generation National Broadband Network (Next Gen NBN) which brought ultra-high speed broadband to over 95% of homes and businesses in Singapore. The IDA also rolled out two fibre connections to every home to instil redundancy and resilience in the network. This ensured that bandwidth would not become a constraint in Singapore's Smart Nation journey.

### Developing Horizontal Enablers

The Smart Nation initiative calls for a whole-of-nation effort, with the public, private and people sectors coming together to co-create solutions. The government plays a leading role in a few ways. As an enabler to innovative businesses and individuals, the government put in place supporting physical and digital infrastructure and policies, such as building core digital infrastructure, fostering a pro-innovation environment, providing funding incentives and growing a digital talent pool. It drives the development of resource-intensive physical networks and digital platforms that serves as core digital infrastructure and leads by example through the digital transformation of the public service. As a smart buyer, the government creates opportunities and incentives for the private sector to develop proof-of-concept and prototypes, and scale up successful pilots that meet its procurement requirements.

The government also engages and empowers citizens in the Smart Nation drive and manages potential negative impacts that can arise from technology disruptions. This entails encouraging active participation among the citizenry in learning new digital skills and integrating digital tools in their daily lives. Citizens are also engaged in providing feedback to the government and businesses on the design and development of digital solutions. Such efforts build a strong foundation that allows innovation to flourish in Singapore.

### Building a Core National Digital Infrastructure

Connectivity is a crucial piece in the Smart Nation puzzle. Singapore's next generation digital infrastructure took the form of the Next Gen NBN, which serves as the foundation of a vibrant digital economy. The rollout of the Next Gen NBN has been largely completed, allowing large and small enterprises, the public sector and households to benefit from the ease of access to ultra-high-speed broadband (see Chapter 2). Dr Vivian Balakrishnan stressed the importance of ensuring that connectivity was pervasive:

*It means in the case of digital infrastructure, making sure that mobile connectivity and broadband connectivity is pervasive. And when I say pervasive, I mean a hundred per cent coverage. An 80-20 principle is not enough because that means you're going to exclude 20 per cent of the people.<sup>133</sup>*

The government also plays a key role in investing and developing shared digital infrastructure, especially digital platforms that serve as public goods or technology "commons", which are resource-intensive and require diverse expertise that few organisations would possess, or are absolutely central to the development and operation of the larger ecosystem. Businesses can then layer their own applications and systems on top of the government-built infrastructure. These are encapsulated in the Strategic National Projects that serve as key enablers for the Smart Nation. These include the National Digital Identity, e-Payments, the Smart Nation Sensor Platform, Smart Urban Mobility and Moments of Life, in which government services are bundled across different agencies to meet a citizen's needs at different stages of life.

At the same time, the government is tapping on the private sector to develop other digital infrastructures such as data exchanges, cross-sector Business-to-Business (B2B) platforms including e-invoicing and industry-specific B2B platforms. These initiatives also help to build local capabilities and develop exportable products and services.

### Investing in R&D and Anchoring a Digital Talent Pool

Through on-going national research and development (R&D) plans and programmes, the government collaborates with private companies, start-ups and research institutions to catalyse innovations and drive new areas of economic growth such as artificial intelligence, cybersecurity and data science. For example, companies have set up laboratories in partnership with local universities such as the Singtel Cognitive and Artificial Intelligence Lab for Enterprises (SCALE@NTU), the ST Electronics-SUTD Cyber Security Laboratory, and the SMRT-NTU Smart Urban Rail Corporate Laboratory. Under the Research, Innovation and Enterprise 2020 (RIE2020) masterplan, Singapore set aside S\$19 billion over a five-year period for R&D, including S\$400 million to support the building of digital capabilities and applications.



From left: Deputy Prime Minister Teo Chee Hean, NTU President Professor Subra Suresh and Permanent Secretary (Public Service Division) Yong Ying-I, looking at the smart home sensors predictive AI for the elderly developed by NTU scientists.

Photo courtesy of Nanyang Technological University.

Singapore also positions itself as a gateway to the Asia market and a “living lab” for test-bedding of smart city solutions. Solution providers can partner public or private asset owners to test and validate technology in a real-life environment. For example, Singapore-based start-up nuTonomy was the first private company to be given the green light to test self-driving taxis in the country.<sup>134</sup> However, the small market can limit Singapore’s attractiveness for testing concepts.

### Developing an Innovation Culture

*...at another—I would argue more fundamental—level, being a Smart Nation calls for innovation at the systems level—aggregating technologies and combining them with new operating concepts, policies and plans—to solve national problems such as the effects of climate change, traffic congestion, an ageing population, or simply to improve service delivery. But its realisation is the sum of many innovations, big and small.<sup>135</sup>*

Peter Ho, former Head of Civil Service

To achieve the bold ambitions for Smart Nation, an innovative culture within the public service and the nation is essential. The government’s approach to innovation and technological disruptions has a strong signaling effect on the wider economy and community. Within the public sector, the IDA, and subsequently the Government Technology Agency of Singapore (GovTech), is granted space to innovate and provide in-house ICT capability to ministries and agencies to support their digitalisation journey. To accelerate innovation within the Singapore economy, the Committee on Future Economy (CFE)—convened in January 2016 to develop economic strategies for Singapore—also recommended several initiatives, including connecting Institutes of Higher Learning and companies with overseas partners through a Global Innovation Alliance.

Beyond cultivating innovation within the public sector, the government acts as a smart buyer and supports start-ups and innovative small and medium enterprises (SMEs) in commercialising and scaling up their solutions, while ensuring that the procurement process continues to provide the government with value-for-money. The MOF worked with the IDA to establish an accreditation programme in 2014, known as Accreditation@IDA (later rebranded as Accreditation@SG Digital), to make it simpler for government agencies to procure innovative digital products from smaller Singapore-based ICT firms. In over a year after the programme’s inception, it created about \$20 million worth of project

opportunities for local accredited companies.<sup>136</sup> Overall, more than 60% of GovTech's budget of S\$2.4 billion for whole-of-government ICT tenders goes to local tech SMEs.<sup>137</sup>

To accommodate start-ups, the JTC LaunchPad @ one-north has grown from a single block into a hive of entrepreneurial activity with some 800 start-ups and 50 incubators.<sup>138</sup> Within the LaunchPad is BASH, Singapore's largest integrated start-up space set up by Infocomm Investments Pte Ltd (IIPPL), a subsidiary of the IDA. BASH runs IIPPL-invested acceleration programmes, which provide mentorship, training and education and networking opportunities to promising technology start-ups. The government also announced a series of schemes under the Startup SG initiative, including co-investment and start-up capital grants.

### Strengthening the Cybersecurity Environment

Singapore's ambition to become a smart nation needs to be built on a secure foundation. As such, cybersecurity underpins the Smart Nation initiative. As the national authority for cybersecurity, the Cyber Security Agency (CSA) drives Singapore's cybersecurity efforts at different levels.

First, at the government level, the CSA works closely with the SNDGO and GovTech to adopt a "security-by-design" approach in the development of the national digital infrastructure. This is critical because any disruption of services or loss of sensitive personal data caused by malicious cyber activity could erode trust in the national digital infrastructure and digital government services. Second, the CSA works with critical information infrastructure owners to strengthen the resiliency of their networks to cyber attacks and minimise the risk of disruptions to the delivery of essential services across Singapore. Third, the CSA works with business associations to prioritise cybersecurity and encourage their members to tap on its cybersecurity expertise and adoption of good cybersecurity practices. Fourth, the CSA also reaches out to the general public to promote basic cyber hygiene practices such as the need to use strong passwords and two factor authentication, and to be aware of phishing emails.

## SEIZING OPPORTUNITIES IN SMART NATION

Building on the work accomplished in the Intelligent Nation 2015 (iN2015) masterplan, a new masterplan for the infocomm and media sectors—Infocomm Media 2025—was launched in August 2015 to guide the

development of the infocomm media sector over the next decade. By then, it was clear that the boundaries between infocomm and media were rapidly blurring. For instance, traditional telecommunications companies that had focused on providing network access were also producing media content, while the media sector were applying increasingly sophisticated infocomm and digital technologies. Coming on the heels of the launch of the Smart Nation, Infocomm Media 2025 was positioned as "enabling and complementing the Singapore Smart Nation vision".<sup>139</sup>

### Reorganising the Regulatory Landscape

*Technology is playing a disruptive role in many sectors and the government must tap on it in new ways to deliver better value to citizens. The formation of GovTech marks a new chapter in the way we use technology to improve the wide range of services and touchpoints that the public sector has with our citizens and businesses.*<sup>140</sup>

Jacqueline Poh, former Chief Executive Officer (CEO), GovTech

The regulatory landscape was restructured to better position the nation to seize new opportunities in the converging infocomm and media space. The IDA and the Media Development Authority (MDA) were reorganised into two new entities—the Info-communications Media Development Authority (IMDA) and GovTech on 1 April 2016.<sup>141</sup> GovTech assumed the IDA's role as the government's Chief Information Officer and would drive digital transformation within the public sector, while the IMDA's role was to develop and regulate the converging infocomm and media sectors, as well as promote and regulate data protection in Singapore.

In particular, GovTech would continue the IDA's Smart Nation initiatives, and lead the government's drive to transform public service delivery through the use of emerging technologies such as data science and analytics, artificial intelligence and machine learning. It would also raise technical capability across the public sector by building and strengthening in-house technical expertise and capabilities in six areas—application development, cybersecurity, data science, geospatial technology, government ICT infrastructure and sensors & Internet of Things (IoT). GovTech directly manages the IT departments of about two-thirds of all government agencies and handles other critical ICT systems for the rest of the public sector.<sup>142</sup>



Placing GovTech at the centre of these efforts would translate into a more integrated approach towards government digital transformation and technology adoption across the public sector. Deputy Secretary of the SNDGO Tan Kok Yam explained that, “[the SNPO had] to be less guerrilla and more organised now that we have GovTech...we set certain standards. We say this is how government IT systems operate, these are things that [the government agencies] cannot build [themselves], this is data that [the agencies] should be sharing and so on.”<sup>143</sup>

### Building a Hive of Digital Solutions

*Government faces an uphill task in attracting world-class tech talent... When we built Hive@Sandcrawler a year ago, it was conceived as a startup-like organisation with the culture to match any Silicon Valley firm. Talented engineers joined us because of a strong sense of purpose in doing good for society and a free hand to make things happen.*<sup>144</sup>

Chan Cheow Hoe, Deputy Chief Executive, GovTech

When GovTech emerged in 2016 from the restructuring of the IDA, the aim of its 1,800-strong crack team was to build core digital capabilities within the government to implement Singapore’s vision of a Smart Nation.<sup>145</sup> The inception of GovTech also illustrated the government’s efforts to transform from having an “inside-out” to an “outside-in” approach, where government services are designed with the needs and perspectives of the citizens in mind, rather than based on the agencies’ internal structures.<sup>146</sup>



GovTech Hive boasts of flexible, open spaces that foster innovation and collaboration.

Photo courtesy of Government Technology Agency of Singapore.

Having traditionally outsourced IT development, the government lacked in-house digital capabilities.<sup>147</sup> Without a good understanding of the technology and digital architecture, agencies found it difficult to update their systems quickly when technology or requirements changed. To rebuild local engineering capabilities and regain control of the IT functions within the public sector, the IDA Hive had been set up earlier.

Located at one-north, the IDA Hive housed the Government Digital Services (GDS) unit which was made of two core teams, the Product Design & Development (PDD) and the Data Science Group (DSG).<sup>148</sup> The PDD team provided consultancy services to other government agencies, while the DSG focused on data interpretation to support public policies and services. The unit started with a small team of like-minded software engineers who saw the potential of technology in transforming government services and embarked on “secret projects” to improve public services.<sup>149</sup> Their efforts were eventually recognized by the IDA’s then-Managing Director Jacqueline Poh and the GDS became official in 2013.<sup>150</sup>

When GovTech was formed, about 75% of the IDA’s staff were assigned to GovTech.<sup>151</sup> The IDA Hive, which became GovTech Hive, continued its mission to develop Singapore’s digital government services and build internal digital capabilities within the government. With its collaborative culture and sense of purpose, the GDS quickly managed to attract tech talent and has grown to about 150 people.<sup>152</sup>

A string of successful projects followed, from internal projects, like measuring the effectiveness of communication campaigns; to public service reforms, such as creating an app, Beeline, to provide on-demand bus services by private operators; and pilot trials, such as using sensors to measure outpatient heart rates. The GDS team also worked with public sector agencies to create resident-centric apps and services like myResponder, a medical emergency crowdsourcing app; the Business Grant Portal, which consolidates government grants for businesses; and the OneService@SG by the Municipal Services Office (MSO). Projects could move quickly. For example, the idea for the myResponder app first came about when GovTech’s Deputy Chief Executive, Chan Cheow Hoe was having coffee with a SCDF commander and the app was developed in less than five months.<sup>153</sup>



myResponder app in action.

Photo courtesy of Government Technology Agency of Singapore.

Rather than starting from scratch, the GDS team often re-adapted elements from one project to another. For instance, the geospatial map for the Beeline app was also used to develop the Birds of Singapore app which allowed nature lovers to geo-tag bird sightings. This was enabled by GitHub, a code repository platform, which gave government departments access to open source codes to build their own apps faster. GovTech also shifted its focus from traditional enterprise IT to digital enterprise IT. The traditional model relied on centralised governance, shared capabilities and large-scale deployments to exploit economies of scale. The digital model, pioneered by the likes of Amazon and Google, thrived on a multi-disciplinary and agile approach that focused on user experience. In order to deliver a digital economy that can drive Singapore's Smart Nation initiative, the Hive had harnessed a wide array of digital technologies and multi-disciplinary skillsets.

*We can't only use a certain technique to solve any one problem anymore. We need to collect data from sensors, including smart phones; we need a data science team that requires professionals who are adept in machine learning and deep learning to analyse the data; we also need to combine them with the administrative side of the house to make it into an application or service. There are so many ways, and that's why we need all of these tools in the toolkit to be able to deliver what used to be delivered by IT in the 1990s.<sup>154</sup>*

Jacqueline Poh, former CEO, GovTech

To expand the digital ecosystem, GovTech also engaged SMEs and individuals to develop solutions. Through GovTech's InnoLeap programme, there were regular sessions organised where public sector agencies could share their issues, and start-ups and SMEs could pitch their solutions. GovTech also created govBuy to be a marketplace where government agencies could outsource microservices to small companies or freelancers.<sup>155</sup> These initiatives connect the government with a wider pool of talent and give smaller companies the opportunity to build up their experience.

### Establishing a Common Sensor Infrastructure

Digital government which places individuals at the heart of designing policies and services, is a key pillar in Singapore's Smart Nation ambitions. To achieve this, Singapore aims to collect better data and make better use of a growing avalanche of data to glean insights on the needs of citizens, help them make more informed decisions, and deliver a more seamless experience across different government agencies. While outdoor sensors had been used by various agencies and companies to collect data, the deployment tended to be ad hoc with limited coordination across service providers.

To address this, the Smart Nation Sensor Platform (SNSP) is being developed to provide a common sensor infrastructure and services such as a data sharing gateway, video and data analytics capabilities. Built around three focus areas—Connect (sensors), Collect (data-sharing) and Comprehend (harnessing data-driven insights), the SNSP was originally spearheaded by the IDA and has since been taken over by GovTech. The SNSP would help public agencies with their sensor deployment needs, sharing of data collected and data analytics to support needs like urban planning, incident response, and provision of public services such as smart mobility and smart utility management.<sup>156</sup>

The SNSP comprises an end-to-end island-wide sensor network for whole-of-government use. It encompasses hardware like lamp posts and public cameras, as well as software that enables sensor data exchange and data and video analytics. Whether they are traffic police cameras, PUB cameras monitoring drains, or security cameras in HDB lifts, the data can be pulled together from various sources onto one integrated nationwide data platform. The SNSP leverages existing urban assets to host sensors and smart devices, which lowers the cost of implementation.

In 2014, the Jurong Lake District, which is being developed as Singapore's second central business district, began serving as a Smart Nation testbed with more than 1,000 sensors deployed for various pilot projects.<sup>157</sup> For example, sensors and cameras were deployed to maximise traffic flows, minimise taxi queues, and keep track of traffic infringements. The government also announced plans to roll out 1,000 sensors across the island to track a wide range of data from air quality to water level to support previously announced projects, such as surveillance in Little India and Geylang, and water level monitoring in the Singapore River and public drains.<sup>158</sup>

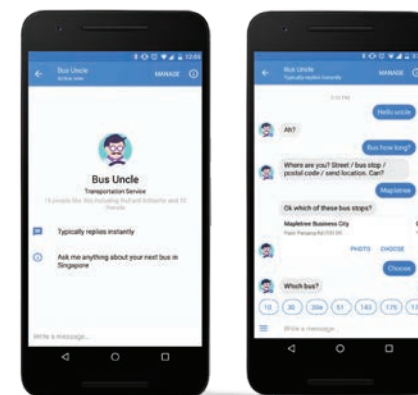
GovTech is also working on a trial to fit ubiquitous lamp posts in Singapore with cameras and sensors and turn them into a network of wireless sensors.<sup>159</sup> The data collected from such smart lamp posts can be used for urban planning as well as operational purposes such as prompt maintenance and incident response.

## Harnessing the Power of Data

*[W]e believe in open data...It does two or three critical things. Number one, it engenders trust, we're not hiding anything...Next...not just publish it, make it machine-readable...make it accessible through APIs [application programming interfaces]. The real objective here is to create an ecosystem where the private sector comes in, meshes government data and their own sources of data, and generates new, innovative services which meet the real needs of real people, makes it more convenient, enhances the quality of life, creates opportunities.*<sup>160</sup>

Dr Vivian Balakrishnan, Minister-in-Charge of the Smart Nation Initiative

To be a Smart Nation, Singapore has to be able to make full use of data. The open data drive by the government is a key pillar of this. Datasets gathered by government agencies have been made available and accessible to the public through online portals. It signalled a paradigm shift for the government to move towards a model where data are treated as a useful resource to be widely shared and mined for insights. The intention is to encourage citizens and businesses to use the data and create solutions that will benefit more people.



Bus Uncle app in action.

Image courtesy of Bus Uncle, [www.busuncle.sg](http://www.busuncle.sg)

The government's open data portal, Data.gov.sg offered over 12,000 datasets—more than 900 are high-quality data in standardised and machine-readable formats—from 70 agencies, ranging from economy, education, environment, health to transport. The Land Transport Authority's (LTA) DataMall gave the public access to approximately 100 datasets, resulting in the development of more than 40 mobile applications and

services.<sup>161</sup> Some of the third-party apps that used data from the DataMall include SG Buses and gothere.sg, which provide commuters with accurate bus arrival timings.<sup>162</sup>

Releasing data encouraged experimentation. Tan Kok Yam, Deputy Secretary of the SNDGO shared the example of the Bus Uncle app, a bus arrival timing app with personality that used government data but was developed by an individual.<sup>163</sup> To facilitate greater participation from the ground, GovTech included a developers' portal in Data.gov.sg so that developers and industry can tap on the APIs to create useful applications. Citizens were also actively encouraged to take part in focus groups in GovTech's Digital Experience Lab and helped refine user experience in the design of digital services.

The government also turned to crowdsourcing for information and resources while enabling the community to participate actively. One of the data science initiatives that came out of the IDA Hive is Beeline, which arranges on-demand express bus services. Using the feedback garnered through Beeline, new bus routes or additional stops along a route can be activated within weeks or days. Significantly, a new route that was introduced using Beeline was full on its first day of operation, attesting to its commercial viability.<sup>164</sup> Another example was a charity, the Singapore Cat Welfare Society, which was one of the first to use OneMap to geotag where streets cats were roaming to plan its sterilisation and feeding programmes.<sup>165</sup>



# SOLVING MUNICIPAL ISSUES AS ONESERVICE

*It's not an easy move. It means breaking down silos amongst agencies, working closely with one another, and arriving at a consensus on how to deal with feedback.*<sup>166</sup>

Grace Fu, former Minister,  
Prime Minister's Office (2012-15)

Every day, the government and Town Councils (TCs) receive some 3,000 public feedback on municipal issues, which often require tight coordination across multiple agencies to address the cases reported.<sup>167</sup> In Singapore, public housing estates are managed by non-government TCs, while municipal issues occurring in the rest of the public areas are largely managed by 11 government agencies. With the corporatisation of the Public Works Department (PWD) in 1999, the responsibility for construction and maintenance of public infrastructure that was previously centralised under the PWD, was divided among various agencies, often on the basis of land boundaries or statutory functions. As Singapore got more urbanised and municipal issues became more intertwined, it became increasingly difficult for citizens and even agencies to pinpoint the relevant agency to provide feedback or seek assistance. Pigeon nuisance, for instance, involved two agencies and the TCs as it pertained to cleanliness, public health and management of birds.

To be more citizen-centric and deliver better services, the “No Wrong Door” policy and the “First Responder Protocol” were introduced in 2004 and 2012 respectively.<sup>168</sup> However, there was still room for improvement. Some cases took a long time to resolve. Others, especially those that needed to be referred across agencies, were lost in transit due to human errors as there was no central tracking system for accountability. Agencies also faced difficulties in sorting out ownership of multi-faceted issues or infrastructure that straddled boundaries.

On 1 October 2014, the government set up the Municipal Services Office (MSO) to improve the coordination of municipal services and transform how agencies work together. The MSO built an integrated case management system, the OneService@SG (OSSG) system, that linked the feedback management systems of 11 partner agencies as well as 16 TCs together. All public feedback in various forms—from letters to emails to transcriptions of hotline calls—are consolidated into a central system. The system tracks cases closely to ensure the cases are being looked into and agencies resolve them promptly. An alert is sent out if an agency has not accepted a case after five working days.

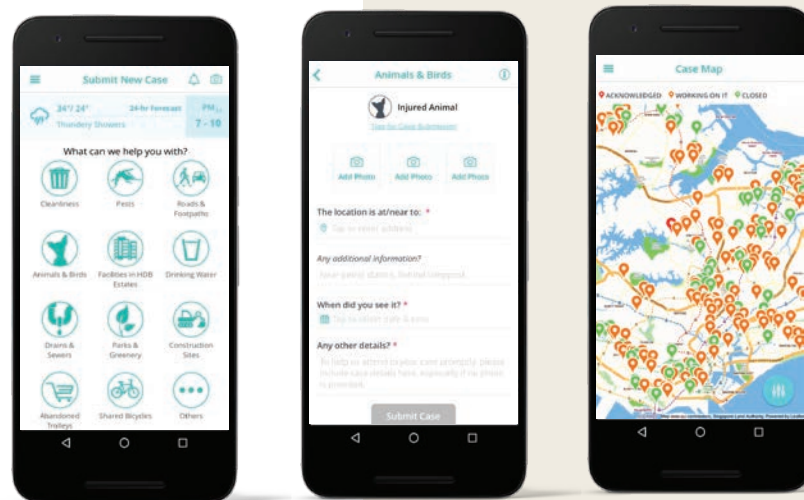
The MSO does not displace the work of government agencies in the provision of municipal services. These agencies continue to take charge of the operations and customer management functions under their respective domains. The public can also continue to direct their feedback to the respective agency. The role of MSO is, however, to help government agencies to resolve municipal issues, particularly where multiple agencies are involved, in a more efficient and coordinated manner, and in turn help improve the living environment

# SOLVING MUNICIPAL ISSUES AS ONESERVICE

Continued...

for Singaporeans. Yip Hon Weng, Senior Director (Policy and Planning) at the MSO, explained:

*We have integrated our system with the Town Council system which allows us to transmit cases using systems—from my system to the Town Councils'. This is really fundamental because Town Councils are not government, and what this also means is that we now have full situational awareness of issues across Singapore.<sup>169</sup>*



The OneService mobile app is designed for users to easily submit feedback and track cases.

Image courtesy of Municipal Services Office.

To simplify the feedback reporting process, the MSO worked with GovTech to develop two OneService (OS) digital products: the OS App and the OS Portal, which were launched in January 2015 and September 2016 respectively. They provided the public with the convenience of submitting feedback on municipal issues without having to first identify the appropriate agency. The public could also tag the location of the feedback and receive case updates. Compared to operating a manpower-intensive hotline, a mobile app was a far more efficient method of crowdsourcing feedback and information from the public, although feedback could still be submitted through offline channels.<sup>170</sup> Using such digital channels also facilitated systematic and comprehensive capture of feedback data, which in turn enabled quicker resolution of issues and better situational awareness. In 2017 alone, the number of registered users and cases submitted grew by 43% and 100% respectively, reaching 114,000 registered users and 153,000 cases submitted.<sup>171</sup>

The data collected are visualised via the Municipal Services Dashboard, an internal planning tool that highlights and analyses key issues within each estate. This highly intuitive and user-friendly dashboard has since been rolled out to the MSO's partner agencies and participating TCs. Using this dashboard, government agencies and TCs gain awareness of municipal issues under their purview, share insights and initiate collaboration to improve upstream planning and joint operations. The Municipal Services Dashboard thus improves service delivery by allowing agencies and TCs to adopt a more holistic and citizen-centric approach to municipal service delivery, better identify residents' needs and respond more proactively to municipal issues.

Since its formation, the MSO has helped improve coordination and feedback management between government agencies and TCs. Moving forward, it will expand its scope to improve upstream planning and operational processes through the use of data-driven insights. The MSO will continue to foster closer collaboration with residents to improve municipal services and build a better living environment for everyone.

## TURBO-CHARGING THE MOVEMENT

*We have set up a Smart Nation Programme Office in the Government, in the Prime Minister's Office, to oversee this exercise and get significant projects moving. I think personally that for all our pushing, we really are not going as fast we ought to.*<sup>172</sup>

Lee Hsien Loong, Prime Minister of Singapore

Nearly three years after the Smart Nation initiative was announced, Prime Minister Lee Hsien Loong voiced his opinion that Singapore was moving too slowly in its digital transformation. While certain areas like transport and e-government services were making significant strides, the progress was uneven.

### Struggles of a Fledgling Smart Nation

The SNPO faced insurmountable challenges during the first three years that it was established. First, technical decisions for ICT systems were often made downstream. The development of government ICT systems was often outsourced to contractors or sub-contractors, who made technical decisions on changes to ICT systems. These decisions were far removed from the policy makers or even system owners. Unlike GovTech which had a 1,800-strong team with deep technical expertise, the lean team of policy makers and planners at the SNPO did not have the same resources to push the Smart Nation agenda at the technical level throughout the public sector.<sup>173</sup> Hence, it became critical to bring technical decision-making closer to policy decision-making to avoid getting entangled in subsequent problems of interoperability between different systems, as Deputy Secretary of SNDGO, Tan Kok Yam explained:

*When it comes down to the nitty-gritty of getting the systems talk to each other and to work together, suddenly, we find ourselves tangled in all these knots which left the decision maker puzzled.*<sup>174</sup>

Secondly, there was the issue of legacy ICT systems. There was resistance among government agencies and companies to move from proven and entrenched systems, or switch to another platform that would allow their data to be shared. Such older systems had been built independently of one other and were not designed to be interoperable. One example was electronic payment services (e-Payment) that suffered from a fragmented landscape of disparate services and systems that lacked interoperability and coordination. This led to an oversupply of e-Payment infrastructure and limited adoption of more efficient payment methods by both consumers and businesses alike.<sup>175</sup>

Another challenge was in ensuring a fair allocation of budget for the development of technical “commons”, shared technical architecture and infrastructure that could be used by various applications and services. Given the cross-cutting nature of such projects, it would be difficult to slice up the financial pie accurately based on the benefits that each contributing agency would get. Tan cited the example of funding for the smart lamp post project. The project first came about because the LTA wanted to switch street lighting to more energy-efficient LED with a remote control and monitoring system. The SNPO subsequently encouraged the LTA to consider exploiting the excess power and communication links embedded in the new street lamps to mount additional sensors that could serve other agencies. While the LTA agreed to do so provided the additional costs were borne by the SNPO or other agencies involved, the question arose as to what could be considered as additional costs. Such incidences highlighted the difficulties of implementing projects that served the technical commons.

The relatively limited private sector participation in the Smart Nation initiative was another area of concern. Unlike other aspiring smart cities like Stockholm and Copenhagen where the private sector was actively involved, the private sector in Singapore appeared to be less forthcoming. Transport was arguably one of the few sectors where disruptions brought on by ride-hailing companies like Uber and Grab had led to rapid and dramatic changes to the industry, and catalysed innovation by local firms. However, its growth was limited by the relatively small pool of deep technology entrepreneurs, software engineers and data scientists in Singapore.



Despite Singapore's efforts to position itself as a "living laboratory" for smart solutions, its small market can be a constraint. Some industry experts also pointed out that the government's heavy involvement in the economy could be a double-edged sword as the private sector tended to take a backseat in the Smart Nation drive.<sup>176</sup> Singapore companies were often perceived as waiting for the government to take the lead in rolling out smart solutions through government tenders.<sup>177</sup> This was compounded by the lack of clarity in the original targets and deadlines for the Smart Nation projects.<sup>178</sup>

Above all, the sheer enormity and complexity of the tasks at hand proved to be the ultimate speed bump for Singapore's Smart Nation journey up till then. In the attempt to be the world's first smart nation, Singapore was in uncharted territory where emerging multifaceted issues like cybersecurity, data protection and data sharing needed to be addressed and resolved through collaboration with all stakeholders.<sup>179</sup> Dr Vivian Balakrishnan, Minister-in-Charge of Smart Nation Initiative offered this perspective on the Smart Nation progress:

*This kerfuffle about how we can't go cashless because some people might find it inconvenient? The answer is not to go more slowly. The answer in fact, is to double down and go faster...We need to speed up revolution and make it so convenient, so painless, so transparent, so seamless, that the objections disappear. That's what we need to do, so the thing is, you can't slow down. You need to speed up.*<sup>180</sup>

### Charting Out a New Approach

To move more swiftly and decisively in the Smart Nation initiative, the government saw a need to adopt an integrated approach and consolidate the expertise that resided across different agencies and government units. This resulted in a reorganisation of the government's approach. In May 2017, the Smart Nation and Digital Government Office (SNDGO) was established under the PMO, comprising staff from the SNPO, the MOF's Digital Government Directorate, and the MCI's Government Technology Policy Department.<sup>181</sup> GovTech, a statutory board under the MCI, was now placed under the PMO as the implementing agency of the various Smart Nation initiatives formulated by the SNDGO.



The newly minted Smart Nation and Digital Government Group overseen by five ministers brought together the master planners, policy makers and implementation teams of the Smart Nation efforts under one roof.

Photo courtesy of Government Technology Agency of Singapore.

*You must have the right degree of centralisation to be able to make things happen and coordinate tightly...This way, we will be able to do it more efficiently and with greater results. Otherwise, we are trying very hard but we are not as tightly coordinated as we could be and it's frustrating.*<sup>182</sup>

Lee Hsien Loong, Prime Minister of Singapore

The SNDGO and GovTech collectively formed the Smart Nation and Digital Government Group (SNDGG). The SNDGG serves as a central governing body for Singapore's Smart Nation initiative and is responsible for working with government agencies to develop digital technologies in key domains like mobility and health, build enablers and platforms, and drive the digital transformation of the public sector. The SNDGG is overseen by a ministerial committee chaired by Deputy Prime Minister Teo Chee Hean and includes the Minister-in-Charge of the Smart Nation Initiative, Dr Vivian Balakrishnan and Minister-in-Charge of GovTech, Dr Janil Puthucheary.<sup>183</sup>

## Exhibit 5

### Organisation Chart for Smart Nation and Digital Government Group (SNDGG)

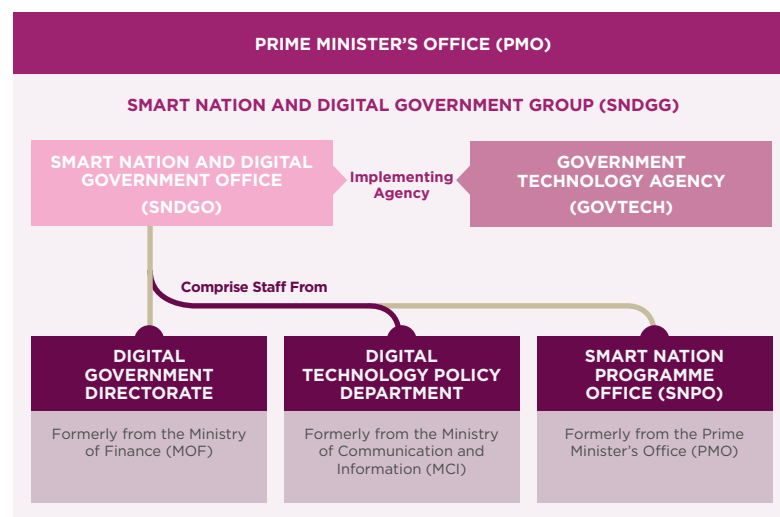


Diagram courtesy of Smart Nation and Digital Government Office.

The restructuring exercise consolidated the efforts of the three key organisations at the forefront of the Smart Nation initiative—the MOF, the MCI and the SNPO. Government agencies, as the domain experts, still own and maintain the bulk of digital services that now come under a coordinated policy framework and shared digital infrastructure. Common standards were set on data sharing and ICT systems operations to ensure a whole-of-government approach. With a strong mandate, the SNDGG takes a more organised approach in charting Singapore's Smart Nation vision.

## Helping Citizens to be Digitally Ready

Amidst the series of Strategic National Projects underway to encourage pervasive adoption of digital and smart technologies, there is a corresponding need to ensure that all Singaporeans are able to seize the opportunities offered by Smart Nation drive. To do so requires a better understanding of the barriers to the adoption of digital technology among the different segments of the population.

Although digital infrastructure such as a National Digital Identity help to drive adoption, applications that can directly address citizens' pain points would also entice more to use them. GovTech and various government agencies have been actively engaging the public through various sessions to understand their needs. One example was Parking.sg, a mobile app jointly developed by the URA, HDB and GovTech that provides a quick and convenient way to pay for parking digitally, replacing the use of paper coupons. Trials conducted in two phases involved more than 15,000 public officers and selected members of the public.<sup>184</sup> With deliberately barebone and limited features, the app was easy to use and turned out to be very popular among motorists—300,000 users downloaded it in three months since its launch in October 2017.<sup>185</sup>





Since 2010, the IDA (now IMDA) organised over 140 Intergenerational IT Bootcamp where student volunteers were paired with seniors to train them in basic IT skills through hands-on workshops.

Photo courtesy of Government Technology Agency of Singapore.

A sustained national effort is necessary to systemically educate and promote the pervasive use of technology among Singaporeans, as well as designing with the user in mind, to achieve a better quality of life. In a pilot for the SEMAS in Yuhua estate, the take-up rate was low as most elderly residents were not comfortable being monitored by sensors around their home. Many also shared that they did not need such monitoring systems as they were still healthy. Only 70 out of 3,200 flats in the estate who were among the first to experience “smart living” in public housing, opted for the installation of the monitoring systems.

The MCI has produced a Digital Readiness Blueprint to ensure all Singaporeans have digital access to technology, have the necessary digital literacy skills, and are able to participate actively and meaningfully in digital living. The government will also use the principle of digital by design, ensuring that all government products and services are by design digitally inclusive. Ultimately, the objective is to ensure that the benefits of technology are enjoyed by all, including the elderly, low-income groups and persons with disabilities.

## CHAPTER 5

# STAYING AHEAD OF THE CURVE



Singapore has often embraced technology to improve the development and delivery of public services and infrastructure, and in some cases, catalyse change in the community. Guided by national infocomm plans and e-government masterplans, the government developed, adapted and applied ICT and smart technologies to reap optimal benefits. Recognising early the vast potential of an increasingly connected world, the government readily invested substantial funds and resources into developing the physical infrastructure—the national broadband and wireless networks—to support the spread of ICT and digital services.

Starting with the computerisation movement, the deployment of ICT has boosted the efficiency and effectiveness of the public sector in diverse areas such as international trade, land use planning, land management, housing and transport. One early success was TradeNet; a more recent example is the OneService targeted at municipal issues. The successful adoption of ICT to suit Singapore's needs has brought greater convenience for citizens and boosted Singapore's economic competitiveness. The greater value however, is arguably in helping to change mindsets and enabling public sector innovation. With the increasing sophistication of digital technologies and data mining tools, the government has found new ways of better serving, and collaborating with, the private sector and the community. This is reflected in the latest Digital Government Blueprint released in June 2018, which laid out the government's ambition to drive broader efforts to build a digital economy and digital society, in support of the Smart Nation initiative.

The growing convergence of the infocomm and media sectors spurred changes in the regulatory landscape as the agencies tasked with the development and regulation of these sectors were restructured to adapt to a changing environment. The Smart Nation agenda also favoured a different approach, leading to the formation of the Smart Nation and Digital Government Office to give shape and coherence to a multitude of Smart Nation initiatives and efforts. For its efforts, Singapore has been recognised as a top-performing smart city in the Global Smart City Performance Index 2017.<sup>186</sup>

Today, the government is gearing the nation up through the Smart Nation initiative for the next digital revolution and its far-reaching impacts on the economy and society. While the digital revolution has created immense benefits and game-changing opportunities, it has also brought new challenges that Singapore has to address.

## CHALLENGES OF REALISING THE SMART NATION VISION

Given the high level of Internet activity in Singapore, the vast amounts of digitalised government information and records, and the extent of government services that are available online, Singapore can be vulnerable to cyber attacks and data breaches. The looming threat of such attacks in Singapore was amply illustrated in late 2013 when several websites, including the government's, were hacked into, despite heightened alert among the public sector's IT security teams.

Infocomm security is not new to Singapore, and in fact, an Infocomm Security Masterplan was drawn up in 2005, and expanded in 2008, to guard against cyber threats. Nevertheless, the 2013 episode emphasised the pressing need to constantly build and strengthen Singapore's resilience to cyber threats, especially as it moves towards its Smart Nation vision. Soon after the launch of the Smart Nation initiative, the Cyber Security Agency was formed in April 2015 to oversee national cybersecurity strategy, operation and ecosystem development. To strengthen Singapore's cyber defences, the government also took the decision of implementing Internet surfing separation for the civil service by blocking Internet access on work computers that had access to the government's internal networks.<sup>187</sup>

Data protection has also come to the fore in recent years, given the incidents of data breaches in private and public sector organisations in Singapore and elsewhere. In Singapore, a data protection law—the Personal Data Protection Act (PDPA)—was phased in between 2013 and 2014. Aimed at preventing the misuse of personal information, the law which is administered by the Infocomm Media Development Authority (IMDA), governs how businesses collect, use, protect, correct and provide access to personal data.

The emergence of new businesses enabled by sophisticated digital platforms which can process vast amounts of real-time data, have also disrupted traditional business models. In some industries such as financial technology, the government has encouraged innovation by setting up "regulatory sandboxes" where businesses are allowed to experiment with innovations in products and services in a controlled environment under the supervision of the Monetary Authority of Singapore.



Having a virtual replica of the city-state was unimaginable five decades ago. Singapore has made good progress in harnessing ICT over the years, bearing fruits of limitless possibilities as it continues to strive as a Smart Nation.

Image courtesy of National Research Foundation Singapore, Singapore Land Authority and Government Technology Agency of Singapore.

While such digital platforms and services have opened up new markets and opportunities, they can also pose new regulatory challenges. Ride-sharing platforms which match passengers with private-hire drivers, and home-sharing platforms which offer homes for short-term rentals, have spread rapidly. Bicycle-sharing was also launched in Singapore in recent years. In home-sharing for example, the dis-amenities imposed on neighbours have prompted a backlash and calls to curtail such short-term rentals. In bicycle-sharing, there have been complaints about the bikes blocking public spaces. Such tensions illustrate the fine line that the government has to tread not only between competing interests, but also in ensuring that Singapore remains open to new technologies and business models, or risk missing new opportunities.

At the same time, Singapore has to continue building up its pool of ICT expertise. The disruptions that accompany technological changes can come at a social cost, and some jobs could become obsolete or be changed drastically. In this respect, initiatives like the SkillsFuture programme and the Professional Conversion Programme, are helping to reskill the workforce with new ICT and other skills. The government also has the task of ensuring that the benefits of technology and the Smart Nation initiative are inclusive and extended to all segments of society. For example, the IMDA is promoting infocomm awareness among the less technology-savvy elderly through programmes such as senior-friendly infocomm learning hubs known as Silver Infocomm Junctions, and digital clinics for one-to-one assistance on smartphone technology.<sup>188</sup>

Singapore's experience with infocomm over the past five decades has helped to shape its vision for the country as a Smart Nation. As the world becomes ever more connected and the pace of disruption enabled by technology grows, one of the biggest challenges ahead for Singapore could be changing mindsets within its public service and citizenry to instil resilience in the face of uncertainties and nurture adaptability to meet constant changes. The Smart Nation initiative is in essence a journey, rather than a destination, and Singapore has made a promising start.

# GOVERNANCE TOOLS AND TIMELINE

- Legislation
- Executive Policies and Initiatives
- Key Institutions
- Others

**1963**

- ▶ The Central Provident Fund (CPF) Board was the first public agency to purchase a mainframe computer for batch processing.

**1966**

- ▶ Ministry of Defence (MINDEF) introduced a computerised system for allocation of national servicemen.

**1967**

- ▶ The South East Asia Commonwealth (SEACOM) submarine cable system was launched.

**1967**

- ▶ Establishment of the Singapore Computer Society (SCS).

**1979**

- ▶ Formation of MINDEF's Systems & Computer Organisation (SCO).

**1980**

- ▶ National Computerisation Programme was initiated by the Committee of National Computerisation.

**1981**

- ▶ National Computer Board (NCB) was formed under the Ministry of Finance (MOF).
- ▶ National Computer Systems (NCS) was created as an IT arm and manpower recruitment vehicle of NCB.

**1981**

- ▶ Civil Service Computerisation Programme (CSCP) was implemented to computerise the civil service.
- ▶ Computerised screening at immigration checkpoints was first implemented at the Immigration Department's head office at Empress Place in June.
- ▶ TRANSYT was introduced to provide an area-wide computerised and adaptive traffic signal system.

**1981**

- ▶ Apple Computer pioneered the manufacturing of personal computers (PCs) in Singapore.

**1984**

- ▶ Data Administration Programme was officially launched as part of the CSCP's masterplan.

**1985**

- ▶ Information of every new birth certificate was stored in the National Registration Department's computer system, and computer-printed birth certificates were introduced.

**1986**

- ▶ National Information Technology (IT) Plan was launched.

**1960s & 1970s****1980s**



**1987**

- ▶ NCB centralised its servers into three large data hubs—Land Data Hub, People Data Hub and Enterprise Data Hub.

**1987**

- ▶ BITNET, a campus-wide computer network, was established at the National University of Singapore.

**1988**

- ▶ Green Link Determining System (GLIDE) was launched to replace the TRANSYT system at all traffic lights in Singapore.

**1989**

- ▶ TradeNet, the first nationwide electronic data interchange system was launched in January.

**1990**

- ▶ MediNet, a value-added computer network for the medical and health care community, was launched.
- ▶ LawNet, a nationwide electronic data interchange system, for the legal services community, was launched.
- ▶ Inter-Departmental Network (IDNet), a civil service-wide computer network linking 23 major government computer centres, marked first major steps towards one-stop, non-stop government services.

**1990**

- ▶ Ministry of Information and the Arts (MICA) established in November, following merger of Ministry of Community Development with Ministry of Communications and Information.

**1991**

- ▶ BITNET expanded into a nationwide computer network, Technet.
- ▶ Singapore's first National Technology Plan issued.

**1992**

- ▶ IT2000 masterplan was launched.

**1992**

- ▶ National Science and Technology Board (NSTB) established in January.

**1993**

- ▶ Computer Misuse Act introduced to address computer crimes; later amended as Computer Misuse and Cybersecurity Act.

**1994**

- ▶ One-Stop Change of Address Reporting System (OSCARS), was launched by National Registration Department to transmit updated addresses to subscribing government agencies.

**1994**

- ▶ Internet became commercially available with the launch of services by SingNet, and later Pacific Internet and Cyberway.

**1995**

- ▶ Launch of Construction and Real Estate Network (CORENET), an integrated electronic data interchange system for the construction and real estate sector.
- ▶ Singapore InfoMAP, Singapore's one-stop home page on the Internet was launched.
- ▶ Automatic Network Travel Time System (ANTTS) was introduced to manage the movement of public buses.
- ▶ Integrated Land Use System (ILUS) was launched to provide comprehensive up-to-date information on land use, buildings and planning related data.

**1996**

- ▶ Government Intranet was launched, supporting the integration of public service functions around processes, instead of departments.
- ▶ Electronic Medical Record (EMR) system was implemented to allow patients' medical data to be easily retrieved and shared among healthcare providers.
- ▶ Electronic Commerce Hotbed programme set up to jumpstart e-commerce in Singapore.

**1997**

- ▶ Government Information Infrastructure (GII), was implemented to support distributed computing and collaboration among government agencies and delivery of rich online services to the government and the public.
- ▶ Singapore ONE pilot was launched at community clubs, libraries and schools.
- ▶ Immigration Automated Clearance System (IACS), a fingerprint technology to enhance security and accelerate airport immigration clearance, was implemented.

**1997**

- ▶ NCB came under the Ministry of Trade and Industry.

**1990s**

**1998**

- ▶ Singapore ONE, Singapore's first national broadband network, was launched.
- ▶ Electronic Road Pricing (ERP) system was introduced.
- ▶ Internet e-filing, the world's first electronic filing system for individual tax payers, was introduced by Inland Revenue Authority of Singapore.
- ▶ Introduction of Government Shopfront, a one-stop electronic storefront which enabled government agencies to conduct Internet commerce using the CashCard.
- ▶ Central Appointment and Referral Systems (CARES), was launched, providing the link between private and public healthcare sector.
- ▶ Land Information Network (LandNet) was launched by the Ministry of Law to provide an online mode of geospatial data exchange.
- ▶ Expressway Monitoring and Advisory System (EMAS), was introduced on Singapore's expressways and major roads to manage road traffic.

**1998**

- ▶ Electronic Transaction Act was passed in July to provide a legal foundation for electronic contracts and digital signatures.

**1999**

- ▶ One Learning Place, the first permanent Singapore ONE training centre, was set up at the Toa Payoh Community Library.
- ▶ First eCitizen portal was launched, giving Singaporeans one-stop, non-stop access to government services presented in user-centric packages.
- ▶ PC Reuse Scheme was launched by NCB to provide lower-income families with refurbished personal computers (PCs).

**1999**

- ▶ Infocommunications Development Authority of Singapore (IDA), was formed by the merger of NCB and Telecommunication Authority of Singapore (TAS).

**2000**

- ▶ Infocomm 21 report was formulated.
- ▶ e-Government Action Plan (eGAP) was launched.
- ▶ Code of Practice for Info-communication Facilities in Buildings (COPIF) was introduced to ensure adequate space and facilities in buildings for info-communication services.

**2001**

- ▶ National Infocomm Literacy Programme (NITLP), a 3-year infocomm literacy programme for citizens, was launched.

**2001**

- ▶ IDA was transferred to an expanded Ministry of Information, Communications and The Arts (MICA).

**2002**

- ▶ NSTB restructured as Agency for Science, Technology and Research (A\*STAR), focusing on research and development capabilities.

**2003**

- ▶ Connected Singapore blueprint was launched.
- ▶ Singapore Personal Access (SingPass), a national personal authentication framework for e-services, was introduced in March.
- ▶ The second e-Government Action Plan (eGAP II), was initiated.

**2004**

- ▶ ONE.MOTORING portal was developed.

**2005**

- ▶ Infocomm Manpower Development Roadmap was announced.
- ▶ Infocomm Security Masterplan was drawn up to guard against cyber threats.

**2006**

- ▶ Intelligent Nation 2015 (iN2015) masterplan, a 10-year national ICT masterplan, was launched.
- ▶ Integrated Government 2010 (iGov2010) masterplan was launched in May.
- ▶ Wireless@SG was launched to develop Singapore's broadband market and accelerate the take-up of high-speed wireless broadband among consumers.
- ▶ Reaching Everyone for Active Citizenry @ Home (REACH), a one-stop government engagement portal, was established.
- ▶ Integrated Planning and Land Use System (iPLAN) was launched.

**2000s**

**2006**

- ▶ National Research Foundation Singapore (NRF) was established.

**2007**

- ▶ Silver Infocomm Initiative was launched by IDA to promote IT awareness and literacy among senior citizens.

**2007**

- ▶ Launch of Apple iPhone (mobile Internet was more widely adopted from 2010s onwards).

**2008**

- ▶ Singapore Geospatial Collaborative Environment (SG-SPACE) was launched as a National Spatial Data Infrastructure (NSDI).
- ▶ PublicTransport@SG was implemented and served as one-stop portal for transport-related information.

**2010**

- ▶ MyTransport.sg, a mobile service for one-touch transport information was developed in March.
- ▶ OneMap, the first major product of SG-SPACE, was launched to serve as an integrated and interactive online geospatial platform between government and the public.

**2011**

- ▶ First phase of the National Electronic Health Records System was rolled out, providing a single health record for each patient throughout the healthcare system.
- ▶ Launch of GeoSpace, a web-based portal to enhance sharing of government's geospatial data.

**2012**

- ▶ Ministry of Communications and Information (MCI) succeeded MICA.

**2012**

- ▶ Personal Data Protection Act was passed to govern the collection, use, disclosure and care of personal data.

**2013**

- ▶ Government agencies transited from the Service-Wide Hosting Environment (SHINE) platform to the new G-cloud platform.

**2014**

- ▶ Launch of the Smart Nation initiative and formation of Smart Nation Programme Office (SNPO) under the Prime Minister's Office (PMO).
- ▶ Launch of enhanced MyTransport app with Journey Planner and real-time information on bus arrival and loading.
- ▶ NRF, SLA, and GovTech unveiled Virtual Singapore.
- ▶ HDB's Smart HDB Town Framework was unveiled, which mapped out the key strategies in introducing smart initiatives to public housing towns.
- ▶ Accreditation@IDA (later renamed Accreditation@SGD) was established to facilitate government agencies sourcing for innovative digital products from smaller Singapore-based ICT firms.

**2014**

- ▶ Municipal Services Office (MSO) was set up under the Ministry of National Development (MND) to improve the coordination and delivery of municipal services.

**2010s**



**2015**

- ▶ The OneService mobile app was released to provide members of the public a convenient means to report municipal issues.
- ▶ Unveiling of JTC LaunchPad @ one-north as home for start-ups and incubators.
- ▶ Announcement of the Smart Yuhua pilot, where some 9,000 Yuhua residents were the first to experience "Smart Living" in an existing HDB estate.
- ▶ HealthHub, a one-stop online portal and app for Singaporeans to access their family's health records, was launched.
- ▶ Opening of Tech Able, a facility to promote the adoption of assistive and infocomm technologies among persons with disabilities and employers.

**2015**

- ▶ Establishment of the Cyber Security Agency Singapore (CSA) to oversee cyber security strategy, education and outreach, and industry development.
- ▶ Hive, a new home for IDA's Government Digital Services team was set up.

**2016**

- ▶ Launch of the Research Innovation Enterprise 2020 (RIE2020) Plan to support research, innovation and enterprise activities for a Smart Nation.
- ▶ Announcement of Jurong Innovation District (JID), an open and innovative urban environment for enterprise, learning, and living.
- ▶ Launch of My Smart HDB Home @ Yuhua where smart home solutions were extended to more residents at Yuhua estate.
- ▶ Opening of the BCA SkyLab, an experiential learning facility and living lab to facilitate test-bedding of building technologies.
- ▶ Launch of Singapore's Cybersecurity Strategy which outlined the country's commitment to build a resilient and trusted cyber environment.
- ▶ Committee on Future Economy (CFE) recommended several initiatives, including connecting institutes of higher learning and companies with overseas partners through a Global Innovation Alliance.

**2016**

- ▶ Reorganisation of IDA and Media Development Authority (MDA) into the Government Technology Agency of Singapore (GovTech) and the Info-communications Media Development Authority (IMDA) to support Smart Nation.
- ▶ Launch of SGInnovate, a new agency formed to support Singapore's start-up ecosystem.

**2017**

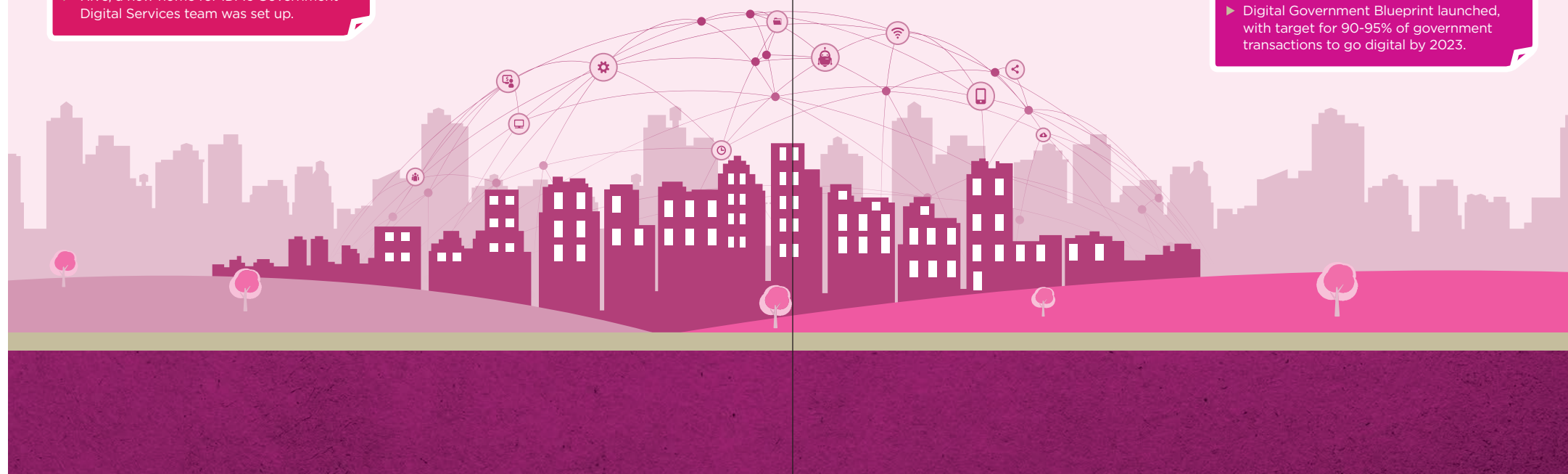
- ▶ Formation of the Smart Nation and Digital Government Office (SNDGO) under the PMO to prioritise and focus the government's efforts on digital and smart solutions.

**2017**

- ▶ Gov.sg bot, the first government chatbot on Facebook Messenger which used machine learning, went live.
- ▶ Launch of AI Singapore, a new national programme to catalyse and boost Singapore's Artificial Intelligence (AI) capabilities.
- ▶ Announcement of the five Strategic National Projects (SNPs) for Smart Nation—National Digital Identity framework, e-Payments, Smart Nation Sensor Platform, Smart Urban Mobility, and Moments of Life.
- ▶ Parking.sg, a mobile app that facilitated digital payment for parking of cars, was launched.
- ▶ Government implemented Internet surfing separation for the civil service in May.

**2018**

- ▶ Release of the Digital Readiness Blueprint to get Singaporeans ready for the digital economy.
- ▶ Digital Government Blueprint launched, with target for 90-95% of government transactions to go digital by 2023.



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## APPENDIX A

### Evolution Of The National IT Plans

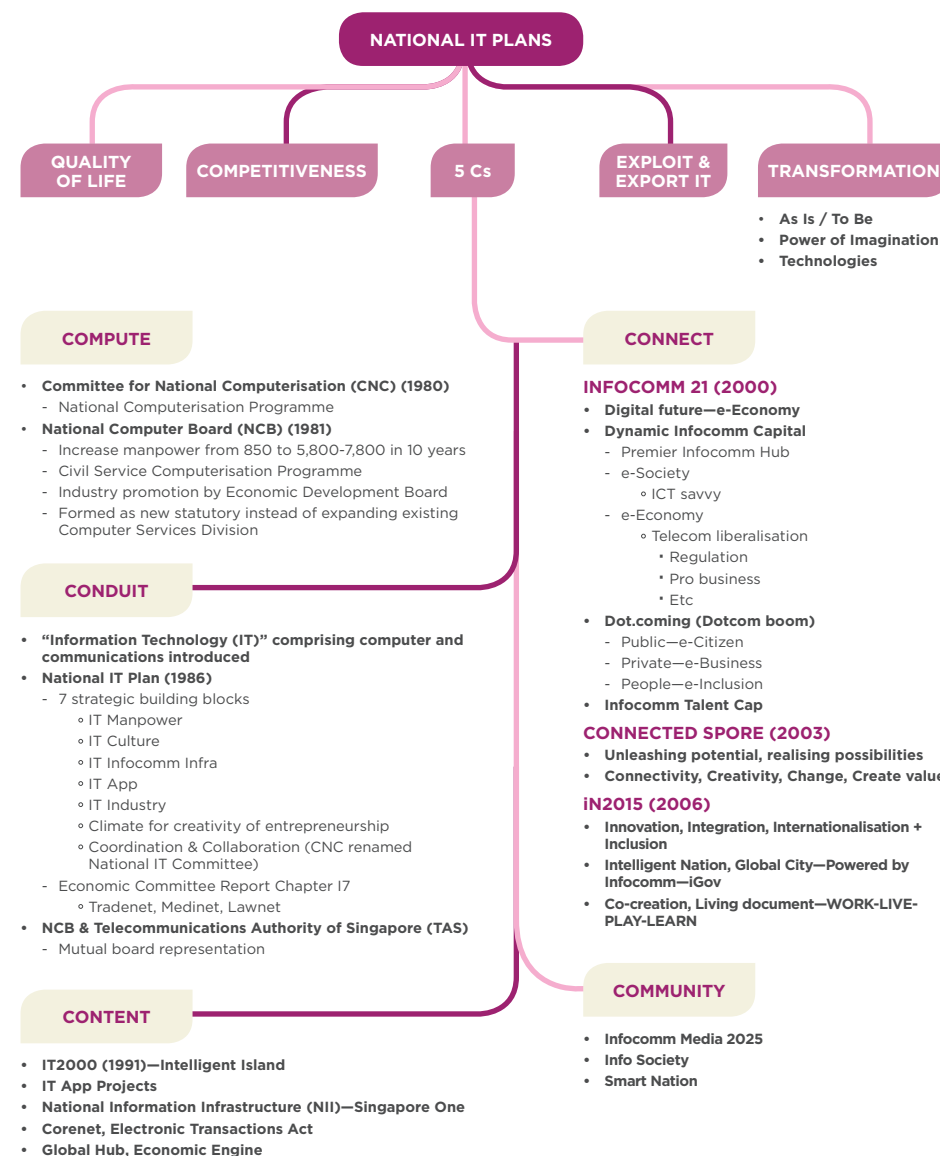


Image courtesy of Dr Tan Chin Nam.



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