

International Case Studies of Smart Cities

Singapore, Republic of Singapore

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International Case Studies of Smart Cities

Singapore REPUBLIC OF SINGAPORE

IDB-KRIHS Joint Research



Abstract

This case study is one of ten international studies developed by the Korea Research Institute for Human Settlements (KRIHS), in association with the Inter-American Development Bank (IDB), for the cities of Anyang, Medellin, Namyangju, Orlando, Pangyo, Rio de Janeiro, Santander, Singapore, Songdo, and Tel Aviv. At the IDB, the Competitiveness and Innovation Division (CTI), the Fiscal and Municipal Management Division (FMM), and the Emerging and Sustainable Cities Initiative (ESCI) coordinated the study. This project was part of technical cooperation ME-T1254, financed by the Knowledge Partnership Korean Fund for Technology and Innovation of the Republic of Korea. At KRIHS, the National Infrastructure Research Division coordinated the project and the Global Development Partnership Center provided the funding.

The smart city initiative of Singapore originated from Smart Nation Vision established in 2014 which seeks to harness ICT, networks and data as a response to growing urban challenges of aging population, urban density and energy sustainability. With its legendary infrastructure, technical advancement and the quality of human resources, Singapore's smart services are expected to be highly advanced. So far, the most developed smart services in Singapore is the Intelligent Transportation System (ITS) with history of more than 10 years, as well as e-government which has been incubated since the early 80s. Smart Nation Vision includes a broad spectrum including smart transport, security, energy, building, education, health and many more, and some services have been launched as trials while others are on their planning stage. Singapore provides an interesting unique case of an entire nation being developed with utilization of highly advanced smart systems and a new form of data sharing platform among various agencies that operate in a discrete manner.

JEL Codes: L86, L91, L96, O18, Q55, R41

Keywords: Smart city, intelligent transport system, urban management, real-time information, smart nation, broad spectrum of smart services

With the collaboration of:



SMART NATION
PROGRAMME OFFICE



LTA ACADEMY
SINGAPORE

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Executive Summary

Singapore is still at its early stage of building their unique version of Smart City. Although a number of different masterplans in previous years have introduced policies that utilize information technology, the smart city initiative originated from Smart Nation Vision established in 2014.

The Singapore Government's Smart Nation vision ideally seeks to harness ICT, networks and data to support better living, create more opportunities, and to support stronger communities, as a response to growing urban challenges of aging population, urban density and energy sustainability. Various stakeholders such as technology builders and entrepreneurs around the world are invited to be involved in this vision to use the nation as a 'living lab' to try out new ideas and smart solutions with global potential. Since Singapore already has a well-structured ground to build its smart nation, with its legendary infrastructure, technical advancement and the quality of human resources, implemented smart services are expected to be highly advanced, and more focused to specific groups of the society.

So far, the most developed smart services in Singapore is within the Transportation and urban mobility sector; the development of Intelligent Transport System (ITS) has been progressing for more than 10 years. Singapore also has a strong e-governance foundation, which they have been incubating since the early 80s. There is a broad spectrum of smart services that Singaporean Government wish to provide for the public but their journey is still at an early stage as most of the services have been launched (many of them as trials) recently in the early 2010s, and many service are on their planning stage, to be implemented along with cross-cutting efforts of the Smart Nation initiatives.

One of the most interesting characteristics of Singapore's Smart Nation is its method of integration among different Governmental agencies. Although specific formation of integrated platform is yet to be fully developed, the underlying idea is to avoid physically integrated platform and instead, to agree on rules and regulations for data integration. Singaporean Government only sees the needs to develop an integrated data sharing platform, where all agencies can access commonly shared information, collected from shared smart sensor network. An interest for Integrated Operation and Command Centre (IOCC) is not there and in fact, this is perceived to have higher risks due to variations in the sensitivity of data. Gathering very senior level of each governmental agency at times of large-scale emergencies is observed to be more safe, efficient, and effective way of managing the city. Therefore, governmental agencies function and continue to function in a rather discrete manner, operating and managing their own operations centre.

Overall, it would be extremely interesting to see how Singapore transforms itself as a Smart Nation. It would provide us with an opportunity to observe a unique case of an entire nation being developed with utilization of highly advanced smart systems, as well as a new form of data sharing platform among a large number of agencies that operate in a discrete manner.



Singapore, Republic of Singapore (Source: <http://globalvillage.world/>)

SINGAPORE

Singapore has its ambition to make its country the world's first true Smart Nation by harnessing technology to the fullest with the aim of improving the quality of life, strengthening businesses, and building stronger opportunities. The country has already begun its journey to bring about the vision it calls 'E3A': Everyone, Everything, Everywhere, All the time. The Smart Nation Platform seem to enable greater connectivity, better situational awareness through data collection, and efficient sharing of collected sensor data. The first phase of the platform that focuses on connect and collect is expected to be completed by the end of 2015.

1. Introduction

1.1 General city overview

Singapore, officially the Republic of Singapore, and also known as the Lion City, is a leading global city-state that is situated 137km (81 miles) north of the equator, and just south of Peninsular Malaysia.

Singapore is one of the most densely populated independent country in the world. The total area is 597km² with population of 5.5 million (as per 2014). It has a diverse populace which is made up of Chinese, Malays, Indians, Eurasians as well

as other Asians of different origins, owning a rather distinctive cultural characteristic. Singapore's territory consists of the main island (commonly known as Singapore Island) and more than 60 smaller islets. Singapore historically experienced extreme turbulence in its early years. During the Second World War Japan had occupied the country, but then it was overtaken by Britain once the War ended. It became independent from Britain in 1963 by uniting with other former British territories to form Malaysia, but was separated after two years due to ideological differences. A small island had to stand up as a nation of its own.

Singapore is somewhat disadvantaged in terms of its geographic location and natural resources. The small island nation sits just one-degree north of the equator, consistently hot and humid year round. The island lacks basic resources; it has no energy deposits, no forests and even no farms. However, despite lacking natural resources and hinterland, Singapore has grown into a global commerce, into an Asian tiger economy based on external trade and its skilled pool of human capital. Today, it has a highly developed market economy. The economy depends heavily on financial services, oil-refining, and manufacturing. Singapore has been ranked "Easiest place to do business" for nine consecutive years by the World Bank and in 2010 it has recorded the highest economic growth (15%) in Asia. According to the World Bank,

Singapore was ranked 4th highest with Int\$ 82,763 GDP (PPP) per capita (as per 2014). As well as prospering economy, Singapore also ranks high on key measures of national social progress which includes education, healthcare, personal safety, life expectancy, etc.

Since Singapore is a small island with a high population density, the number of vehicles on road is restricted to limit pollution and congestions. Vehicle owners are required to pay for high duties (one-and-a-half) times the vehicle's market value, and bid for a Singaporean Certificate of Entitlement (COE), which allows the vehicle to run on the road. Therefore, despite the population of 5.5 million, only 0.65 million vehicles are registered and other transport

modes such as foot, bicycles, bus, taxis and train (Mass Rapid Transit or Light Rail Transit) are used more generally.

Internet access is readily available in Singapore. According to 2010 Report Infocomm Development Authority of Singapore, about 83 per cent of households in Singapore had access to at least one computer at home, and the proportion of households with Internet access increased to 81 per cent (both as of 2009). Mobile phone penetration also remains strong at over 137 per cent, or more than 6.8 million mobile subscriptions.

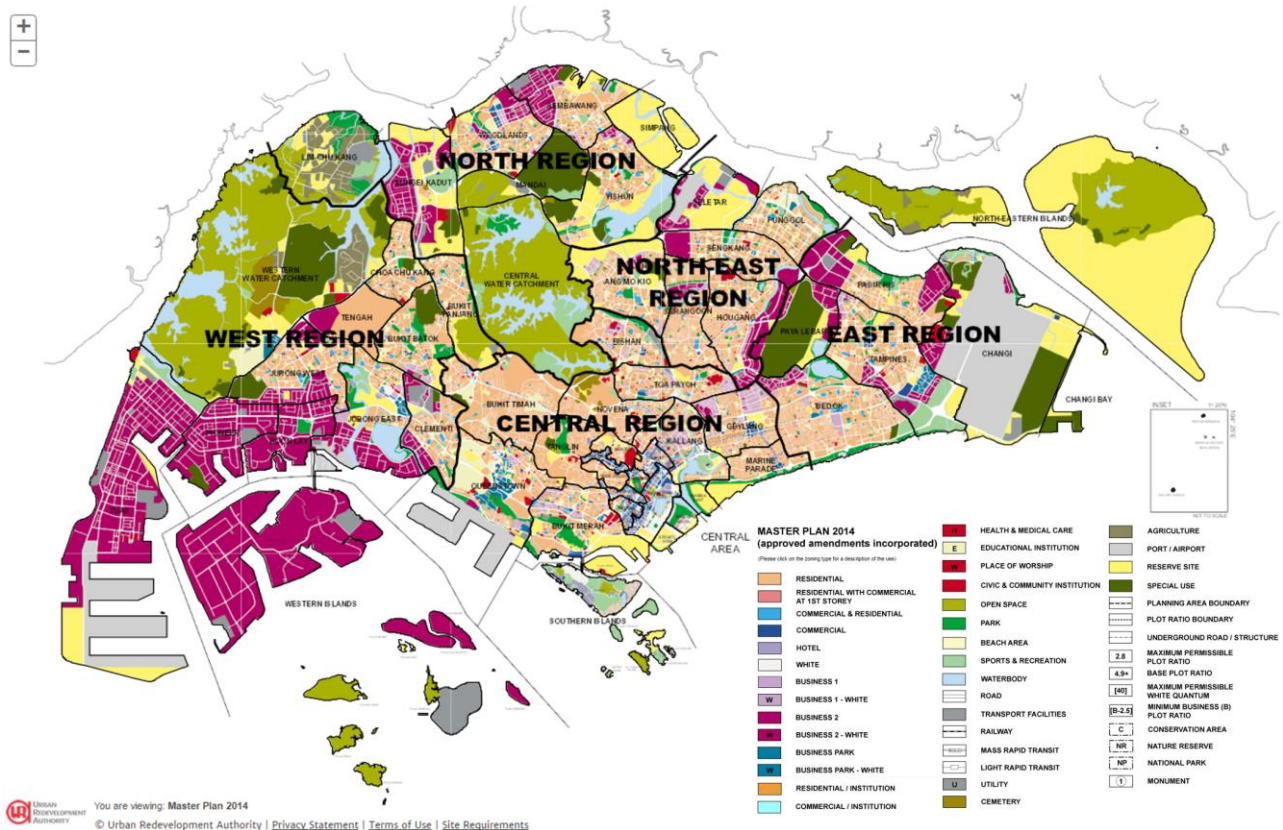


Figure 1 Masterplan of Singapore 2014
Source: Urban Redevelopment Authority

1.2 Smart city overview

1.2.1 Development background and history

As one of the city-state in the world, Singapore's conditions are rather unique. Main urban obstacles tend to originate from the small land

size. Singapore is constantly faced to reconcile livability, environmental sustainability, and economic competitiveness more than other cities round the world, especially amid increasing urban density with population growth. The compact city environment exacerbates traffic congestion, difficulties in maintaining a livable environment with adequate greenery, transport

and housing provision. Moreover, since Singapore is not just a city but a sovereign state, the need to accommodate activities within the city site that are typically located externally to a city like airports, seaports, utilities such as waste treatment plants and power stations, as well as military bases, etc. adding to further crowdedness.

Singapore is also experiencing other urban challenges such as aging population together with declining birth rates. According to 2012-2015 National Population and Talent Division (of Singaporean Government), the Baby Boomers will turn 65 years old from 2012 onwards, and the number of elderly people aged 65 years and above in Singapore is expected to triple to 900,000 (1 in 5). Singapore is to experience unprecedented age shift and those elderly will need to be supported by only a small working-age population.

Realising that these challenges require a smart response, Singapore saw the needs to think of long term and integrated approach to ensure that it develops in a sustainable manner, without disregarding clean and green environment. Singapore many years ago established its ambition to become the smartest city of the world. The Government has been engaging in a meticulous attempt over the years; every 10 years since 1971, Singapore issued a concept plan with a long term (40- to 50-) year time frame and every 5 years, more detailed plans on smart growth. As a result, Singapore is already an intelligently advanced city, equipped with integrated ICT technology to its city features. A network of sensors, cameras and GPS devices are embedded in taxi cabs tracking traffic, predicting future congestion and informing all drivers to alternative routes. The use of special RFID cards is common and the city's water management system is among the world's most advanced system (please see 2.2 for further information).

The smart metropolis that exist today was the vision of Lee Kuan Yew, who was the first Prime Minister of Singapore, governing for more than

three decades from 1959 to 1990.

First Concept Plan was established after Singapore became a self-Governing State. At the time, the Planning Department within the Prime Minister's Office was also set up to take on the role of central planning authority. They were given the power to control the development of land and to amend the master plan every five years if necessary. The Government, however, realized that strategies within master plan is inadequate to match the rapid social and economic changes in Singapore and sought the help of the United Nations, which eventually led to the launch of the State and City Planning Project (SPC) 1967. The result of the completion of SCP in 1971 was Singapore's first concept plan, a long-term plan that showed broad direction of the Government's land allocation and transportation policy. The concept plan envisaged the development of all areas of the city (high and low density residential areas, commercial centres, industrial areas, etc.), as well as a network of expressways and a mass rapid transit (MRT) system to provide nationwide interconnectivity.

The task to review the concept plan and adapt to changing needs of the Singapore was undertaken by the Urban Redevelopment Authority (URA). The revised concept was finalized in 1991, and by then, the majority of Singaporeans were already properly housed. The next target of emphasis therefor shifted to improving the quality of life; the revised plan proposed a wider variety of housing, more leisure facilities and more greenery.

In more recent years entering into the 2000s, the development plans aimed to make Singapore a thriving world-class city. In 2006, the Intelligent Nation (iNation 2015) Master Plan was launched, which is Singapore's 10-year plan to realize the vision of Singapore being an Intelligent Nation, global City powered by Infocomm (information and communications technology). This plan is overseen by Info-communications Development Authority of Singapore (hereinafter iDA), who

are currently undertaking a new vision of 'Smart Nation'. The iDA is working with citizens and companies to develop smart nation solutions.

1.2.2 Vision, current and future projects

Now Singapore is pushing towards the vision of being the world's first Smart Nation under the Smart Nation Program developed in 2014, which ideally seeks to harness ICT, networks and data to support better living, create more opportunities, and to support stronger communities. While various cities around the world are experimenting with the concept of 'smart city' by making the use of technologies to tackle wide range of urban challenges, Singapore has a much

more ambitious and whole-of-nation vision.

The Singapore Government's Smart Nation vision is a response to growing urban challenges of aging population, urban density and energy sustainability. Various stakeholders such as technology builders and entrepreneurs around the world are invited to be involved in this vision to use the nation as a 'living lab' to try out new ideas and smart solutions with global potential.

A critical role of ICT standards is to enable the integration and interoperability of different ICT systems that is in place for Smart Nation initiatives. Achieving such integration is expected to facilitate the optimal use of resources across different systems.

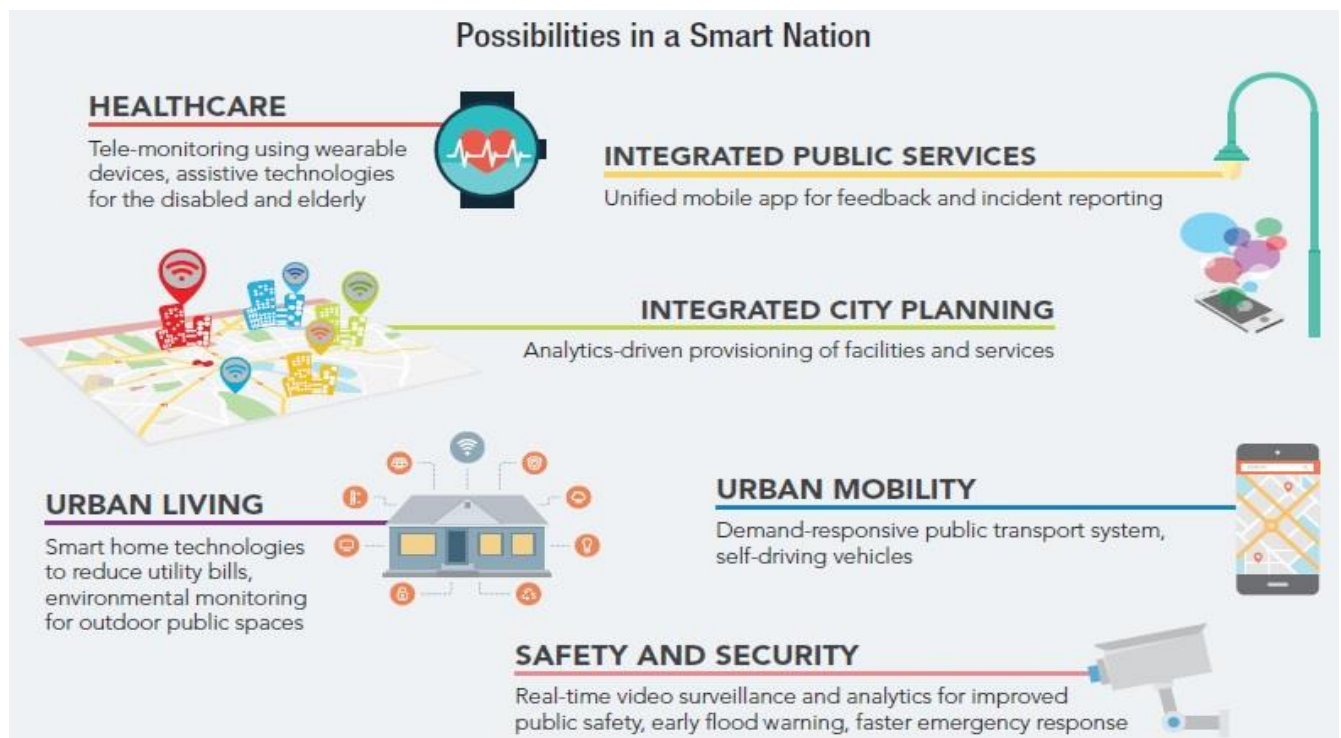


Figure 2 Possibilities in a Smart Nation
Source: Innovating for A Smart Nation, iDA

Towards Being World's First Smart Nation

Singapore is building a Smart Nation that functions beyond the capabilities of a Smart City. With an ultra-high speed, pervasive, intelligent and trusted ICT infrastructure, as well as a vibrant ICT ecosystem with a ready pool of tech talent, which are achievements of the iN2015 masterplan, Singapore is ready to be a Smart Nation.

WHERE SINGAPORE STANDS TODAY



DIGITALLY-ENABLED POPULATION



SKILLED TECH TALENT

Singapore is home to more than **146,000** Infocomm professionals, with a wide range of training and development opportunities.

nictf
NATIONAL INFOCOMM COMPETENCY FRAMEWORK (NICF)
Continual Education Training Centres to develop and launch NICF accredited courses in areas such as strategic IT risk management and enterprise business analytics.

CORPORATE PARTNERS FOR PROFESSIONAL DEVELOPMENT
Centres of Attachment and Company-Led Training Programme to equip both young and experienced tech talent with expertise to take on higher-value ICT roles.

VIBRANT TECH INDUSTRY & STARTUP ECOSYSTEM

Key IDA initiatives – IDA Labs, Accreditation and Accelerator – to boost the tech ecosystem.

IDA LABS support the collaboration of individuals, companies and government agencies to generate innovative IP from ideation to production.
ACCELERATOR are to build high growth Singapore-based tech product startups.

STARTUP INVESTMENT
S\$1.7 billion in venture capitalists' funding for Singapore-based technology companies in 2013.
*Data from Asian Venture Capital Journal

Accredited
ACCREDITATION@IDA aims to help innovative tech product start-ups build their credentials as qualified vendors to government and large enterprise buyers.

TECHNOLOGY-ENABLED SECTORS

Singapore continues to drive adoption of tech to enhance innovation and productivity among the various economic sectors.

NATIONAL ELECTRONIC HEALTH RECORD
has been deployed to **36** healthcare centres, including hospitals, specialist clinics and polyclinics.



ICT FOR PRODUCTIVITY AND GROWTH (IPG) PROGRAMME
S\$500 million for small and medium enterprises (SMEs) to step up on the adoption and innovative use of ICT.

COMPREHENSIVE ONLINE GOVERNMENT SERVICES
Nearly **98%** of public services in Singapore are available online, the majority of them being transactional in nature.
*WASEDA – Government ranking survey 2014



EFFECTIVE LEARNING AND TEACHING
All schools have implemented Infocomm Competency Training in their curriculum. **50** applications rolled out from the Futureschools programme.



SEAMLESS & PERVASIVE CONNECTIVITY

n
Next Gen Nationwide Broadband Network
SINGAPORE'S WIRED NETWORK
NGNBN achieved nationwide fibre coverage since mid 2013. More than **550,000** subscribers served by **27** different service providers.

Wireless @SG
Hotspots to increase to **10,000** by 2015, and to double to **20,000** by 2016.

4G
FOURTH GENERATION
Telecommunication services deployed nationwide since June 2013.

TRUSTED REGULATORY FRAMEWORK

PERSONAL DATA PROTECTION
Do Not Call Registry launched on 2 January 2014, with **> 600,000** numbers and about **3,000** organisations registered.



ENABLING SPECTRUM EFFICIENCY
To regulate use of TV White Space spectrum band, increasing capacity and data connectivity, and allowing consumers to access more options for wireless services.



Figure 3 Building blocks of Smart Nation Vision

Source: Towards Being the World's First Smartest Nation, iDA

2. Service Spectrum

2.1 Overview of the smart services and high level functions

The most developed smart services in Singapore is within the Transportation and urban mobility sector; the development of Intelligent Transport System (ITS) has been going on for more than 10 years. Singapore also has a strong e-governance foundation, which they have been incubating since the early 80s. There is a broad spectrum of smart services that Singaporean Government wish to provide for the public but their journey is still at an early stage as most of the services have been launched (many of them as trials) recently in the early 2010s, and many service are on their planning stage, to be implemented along with cross-cutting efforts of the Smart Nation initiatives.

2.2 Transportation and urban mobility

Singapore has implemented a sophisticated ITS to enhance traffic flow and to keep road traffic running safely. The strength of the ITS in Singapore originates from its holistic approach towards traffic management; ITS work together with other transport initiatives such as free public transportation in pre-morning peak hours, a vehicle quota system, well-functioning public transport system and congestion charge, to enhance overall transport system in the city. Utilizing ITS components, Singapore provides a number of smart transport services for citizens.

A. ONE MOTORING

ONE.MOTORING is the comprehensive portal serving all drivers and vehicle owners in Singapore. On this web portal, citizens can access traffic information collected from surveillance

cameras installed on roads and taxi vehicles with GPS. Through Traffic Smart, drivers are able to see snapshots of roadways that is taken at every 5-minute interval. Due to security reasons, real-time moving video or close-up shots are not provided online.

It also provides information on current ERP rates (Electrical Road Pricing), sections where road works are in progress, traffic images of major expressways, traffic news, travel time calculator, road maps and street directions, and parking information. This useful portal can also be accessed on mobile devices. One motoring, not only provides traffic information but also offers information and guidance for citizens regarding buying, selling and maintaining their vehicles.

B. Express monitoring & advisory system (EMAS) vehicle recovery service (VRS)

The Land Transport Authority (LTA) uses surveillance cameras to look out for road incidents. When an incident is detected, LTA activates the vehicle recovery crew that aims to reach at site in about 15 minutes to tow vehicle to the nearest designated car park outside the expressway.



Figure 4 Expressway monitoring advisory system
Source: LTA

C. Your Speed Sign

'Your Speed Sign' is a smart, live electronic device which displays the real-time speed of vehicles and alerts drivers if they are violating the speed limit. It encourages drivers to stay under the limit and thus improve safety on the roads.

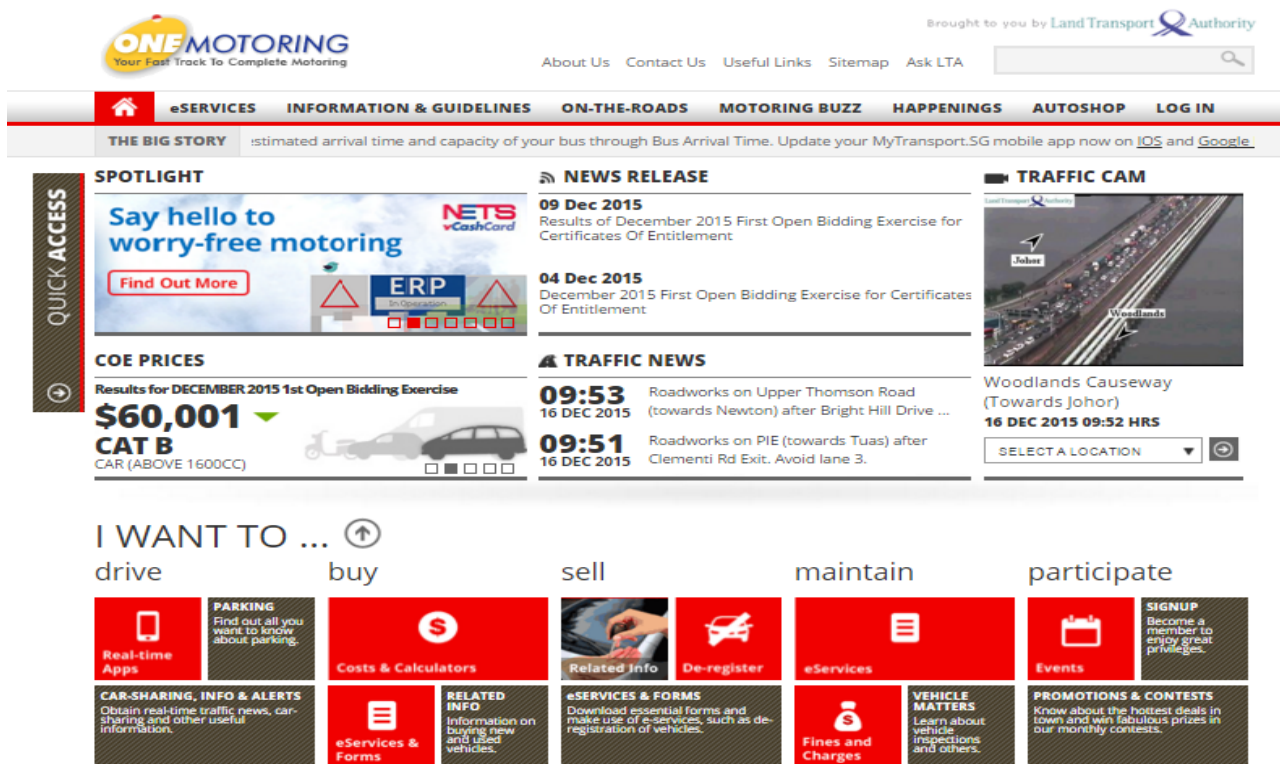


Figure 5 OneMotoring Website main page
Source: www.onemotoring.com.sg



Figure 6 One Motoring traffic cameras, Pan-Island Expressway (PIE)
Source: OneMotoring Website



Figure 7 Your Speed Sign
Source: One Motoring official website

D. Parking guidance service

LTA has launched the Parking Guidance System since 2008 and this provide drivers with real-time information on parking availability. This reduces the amount of circulating traffic searching for available spaces and promotes a more efficient use of existing parking facilities. Information is displayed on electronic sign board or online on One Motoring Portal, or on mobile application such as MyTransport.SG.

Next step in transportation sector under the Smart Nation Vision is anticipated to bring something more advanced and new. Public buses may be unmanned in a near future as autonomous vehicles or self-driving cars have become a reality. Autonomous driving may be applied to other things, for example cargo trucks operating only at night, reducing road congestions during the day.

D. Bus information system

MyTransport.SG smartphone application provides real-time information for commuters. It updates its features regularly to improve

commuters' travelling experience.

Over the past year, LTA has been working with SBS Transit and SMRT to install and test a new centralized system, which determines real-time bus location, and hence provide more accurate bus arrival information for more than 4,700 public buses over 360 routes. Bus loading information is also available for selected bus services. Commuters are able to see colour-coded space availability information to help them decide whether to board the arriving bus or choose to get on the next bus. The colour green indicates available seats, yellow indicates available standing spaces, and red indicates limited standing.

Various applications developed by My Transport Singapore, brought to citizens by the LTA are available to enhance commuters' and drivers' convenient urban mobility.

MyTransport.SG Mobile

Be empowered for an all new travelling experience

MyTransport.SG Mobile, an award winning app, is a content-rich service offering a wide range of information for all modes of land transportation - empowering commuters, motorists and cyclists in Singapore to make informed decisions and better plan their journey, with these features:

- Enhance your travel experience using the public transport Journey Planner
- Personalise your favourite services with MyConcierge
- Search and locate nearby bus stops and service number with bus route details
- Plan your journey through checking estimated Bus Arrival Time and capacity of your bus
- Get real-time island-wide bus arrival information
- Search and locate nearby taxi stands and quick dial for taxi booking services
- View images of 7 selected taxi stand queues
- See timestamp update from the last refresh in Taxi Services at selected taxi stands
- Use the friendly user-interface Snap & Send feature to report on road defects
- Get real-time parking lots availability for popular locations
- Plan route with Traffic News and ERP Gantries on Traffic Smart
- View live traffic images along all expressways round the island
- Receive notification on expressways traffic news during peak hours and train service delay information
- Explore cycling towns, routes, and parking facilities

Download the app from the App StoreSM and Google PlayTM today!

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More Reasons to Download!

Figure 8 MyTransport.SG mobile application
Source: MyTransport official website

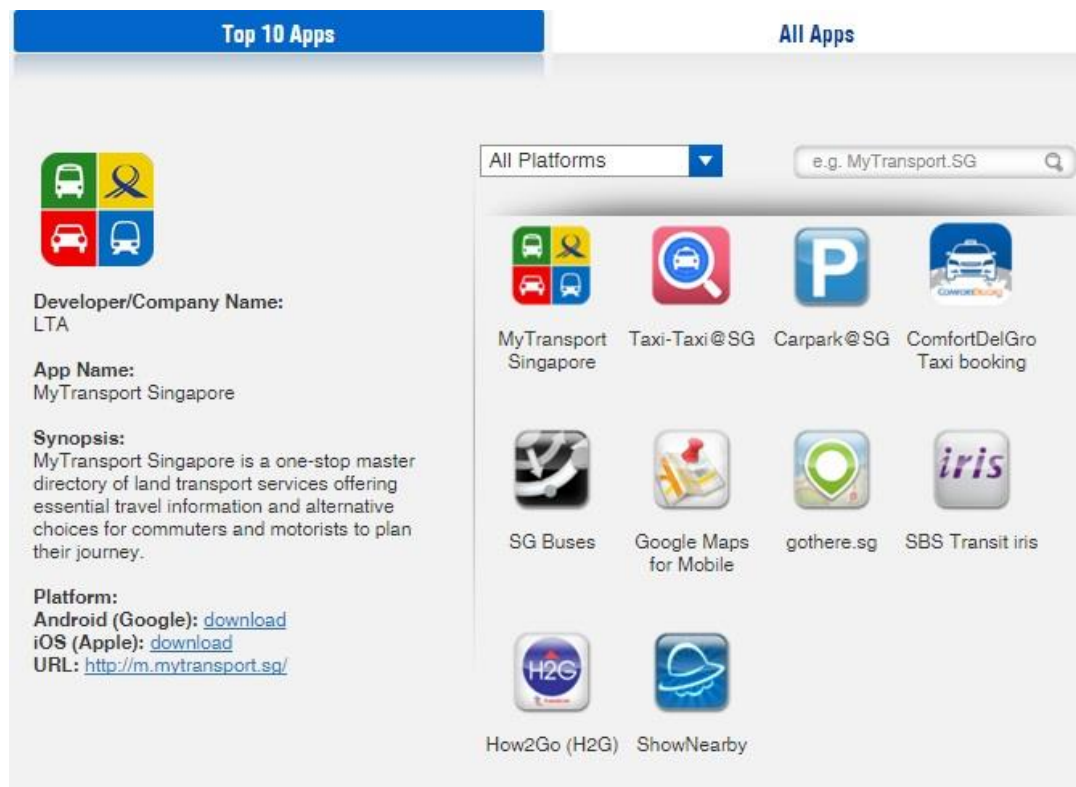


Figure 9 Available applications, top 10
Source: MyTransport official website

2.3 Safety and citizen security

Singapore is the world's second safest city according to the report by the Economist Intelligence Unit. Singapore Police Force has specific targets of service pledge to operate efficiently. Police force can be reached at emergency by dialing '999', and it has separate police hotline (1800-255 0000) as well as a traffic hotline (6 547 0000). There is a SMS service called the Emergency Short Messaging Service Helpline, or SMS 70999 in short, which is designed to offer members of deaf, hard-of-hearing and speech-impaired community another avenue of communication. The project is supported by the Ministry of Finance and iDA. This initiative is in line with the strategic vision of Government's 2010 masterplan that aim to increase the available Government e-services.

The Police Force of Singapore also provides web-based electronic police centre (through Electronic Police Centre, ePC) for citizens to conveniently gather information, file police report online, and

handle administrative affairs such as applying for certified copy of police reports, criminal records, etc. For example, CrimeStopper on ePC provides an alternative online avenue for citizens to make less urgent reports, or submit information to help Police in combating crime.



Figure 10 Electronic Police Centre
Source: Singapore Police Force official website

2.4 Emergency and response

The Singapore Civil Defence Force (SCDF) is a uniformed organization, overseen by the Ministry of Home Affairs of Singapore Government that provide fire-fighting, rescue and emergency medical services; relieve hazardous materials incidents, as well as

formulate, implement and enforce regulations on fire safety.

Emergency Medical Service (EMS) is operated by the SCDF and it can be reached through three-digit dial '995'. The 995 Operations Centre can also be reached through mobile application that SCDF provides in collaboration with iDA, which has been designed to increase survival rate from incidents such as out-of-hospital cardiac arrest. The application so-called myResponders has been launched recently in April 2015 which alerts users to nearby cases of suspected cardiac arrest, guiding them to respond before the SCDF arrives. Since the application was launched, there have been more than 2,000 downloads, although the number of registrations to become responders did not reach the similar level so far.



Figure 11 myResponder App

Source: Singapore Civil Defence Force official website

'mySCDF' allows citizens to provide feedback to SCDF, instructions for use of fire extinguisher, how to perform CPR and AED, as well as access for SCDF annual reports.

Other applications that allow the public with access to critical emergency information are 'Biological Threats', 'Decontamination Procedures', 'Exposure to Biological Agents', 'Fire Safety', and 'If An Explosion Occurs'.

Some e-services are also available on SCDF's main website. These services include: i) online payment for SCDF's services; ii) apply for courses at SCDF for public education programmes; iii) purchase fire and ambulance reports; and iv) SCDF facilities locator.

Another major aspect of Smart Nation initiative that is on its way is tele-medicine. Singapore aim to promote the widespread use of wearable technologies such as fitness trackers, smart

watches and even smart clothing which can monitor the well-being of a patient. The idea is not only to record of vital signs such as blood pressure, heart rate and body temperature and but also transmit the data via Internet to designated healthcare professionals or family members.

IDA established its plan for Smart Health-Assist pilot project in the Jurong Lake District in late 2015 to support the needs of the aging population of Singapore. It is designed to record data from user-friendly sensors in the houses of the elderly and the patients suffering from chronic diseases to be sent securely online to healthcare providers, allowing them to monitor individuals, receive alerts, and respond to any emergencies.

2.5 Environment

As a small nation, Singapore has little land to collect and store rainwater. Water shortages is going to be a continuous challenge for Singapore with ever-increasing demand and therefore, Singapore had to be inspired to innovate and develop capabilities in the area. Under the Ministry of Environment Water Resources, there are two statutory boards, the National Environment Agency (NEA) and Public Utilities Board (PUB), the national water agency. NEA controls air and water pollution, handle waste management, promote energy efficiency, promote public hygiene, etc. while PUB deals with all matters regarding water in Singapore.

To involve citizens in increasing water-use efficiency, the national water utility sends water efficiency messages to the public. The Singapore Power also provides mobile application that allow citizens to view their outstanding bills and payment status, gain better understanding of the utility usage and submit meter readings. This leads for consumers to audit their home usage to manage their water consumption.

In 2015, smart waste bins were introduced as a part of smart waste management program. The

sensing monitors attached on bin lids collect information on contents and location and this is notified to a garbage team through a central server. This helps the waste collection team to optimize their route planning and at the same time, constantly keep the public spaces clean.



Figure 12 Smart waste bin
Source: Gaia Discovery website

The pollution level are monitored by NEA and is available for public on its official website. For example, citizens can easily access information of 24-hour PSI value, the integrated air quality reporting index online.

2.6 Energy

A smart Singapore aims to be energy-efficient and eco-friendly. With smart sensors embedded inside, household appliances such as lights can be automatically turned off when no one is at home. Smart lighting systems in office buildings that detect motion and adjust automatically is available.

For more efficient energy use, Singapore's Intelligent Energy System (IES) attempts to improve network operations and facilitate active participation among consumers. Smart meters that are equipped with communication capabilities play an especially vital role in allowing the system to be two-way channel. They provide both consumers and the grid operator with information on how much electricity they are using.

In 2012, as a part of IES project under phase 2, smart meters were installed at some 1,900

households in Punggol. Some selected residential households were given in-home display (IHD) units, which is a portable device that provides households real-time information about their electricity consumption.

The pilot project was considered to create positive impacts and now through smart meters placed at home, consumers are able to monitor their energy consumption, select their electricity retailer, as well as choosing their own energy package that best suit their needs.



Figure 13 Intelligent Energy System, in-home display unit pilot project at Punggol
Source: Energy Market Authority official website



Figure 14 In-home display (IDH) unit
Source: Energy Market Authority official website

2.7 Citizen interaction and communication mechanisms

As a connected nation with extremely impressive wireless broadband connection rate and smart phone penetration rate, Singapore has emphasized the importance of connectivity between the Government, industries and its people. Most of Singapore Government's main

websites have developed more citizen-central contents and much of information are transferred to citizens through social media and mobile applications.

Plan	Objectives
e-Government Action Plan (2000–2003)	To provide as many public services online as possible
e-Government Action Plan II (2003–2006)	Improvement of the service experience of customers
iGov Masterplan (2006–2010)	Focus on creating an integrated Government that works behind the scene to serve users better. Mobile services were introduced to work with the high mobile phone penetration rate, providing citizens with an additional channel for accessing public services.
eGov2015 Masterplan (2011–2015)	Aim to become a collaborative Government that facilitates greater co-creation and interaction between the Government, the citizens, and the private sector to bring greater value for Singapore. This plan aim to shift from a “Government-to-You” approach to a “Government-with-You” approach in delivery of the online services. The goal is to encourage for more interactions.

Table 1 e-Gov in Singapore
Source: Singapore eGov official website

Not surprisingly, Singapore is already a leader in terms of its e-government platform. It has started

its journey as early as 1980s with the goal of transforming the Government into a world-class user of information technology. In the 1990s, information technology and telecommunications began to converge, transforming the concept of service delivery. This has led to the launch of the following e-Government plans as follows:

Singapore’s e-Government is run by the Ministry of Finance (MOF) and the iDA acts as the Chief Information Officer for the Government. iDA provides technical advice and recommendations, masterplanning and project management services to MOF and other Governmental agencies for management and implementation of e-Government services (programmes).

E-Government Programmes are divided into as three categories, programmes for citizens, programmes for businesses, and programmes for Government. Below are examples of some programmes of each category.

A. Programme for Citizens

1. data.gov.sg

Launched in June 2011, it provides easy discovery of ad access to publicly-available Government datasets. Data.gov.sg provides access for data catalogue for the public and allows download of Government data, search for applications developed using Government data.

2. OneInbox

Launched in December 2013, this programme provides official Government platform where individuals can receive the government-related correspondences electronically. Free digital service is accessible for anyone with SingPass. It offers choice of e-letters, forwarding and downloading or printing of e-letters, forwarding of e-letters to personal email account, etc.

3. SingPass

SingPass was launched in July 2015, which is an authentication system to access all Government e-services.

Other programme for citizens include: charity portal that provide efficient services for charities and donors, e-Visitor that provides information for tourists, etc.



Figure 15 eGov programmes for citizens
Source: Singapore eGov official website

B. Programme for Business

Some programmes are provided for business through e-Government Platform. Launched in February 2004, Business Incentive Profiler provides businesses a one-stop access and application for all Government grants available to businesses. OBLIS allows business to apply, update, renew or terminate any online business licenses issued by government agencies online. Other programmes include the Government Electronic Business (GeBIZ), which is one-stop e-procurement portal and OneMap that is an integrated online geospatial platform where reliable and accurate location-based information and services are provided to public.

C. Programmes for Government

Programmes for Government include The Government Cloud (G-Cloud) that provides a secure ICT shared environment for government agencies, Cube that provide social networking platform among public officers to exchange ideas,

which Infocomm Security Masterplan which serves to guide Singapore's national-level attempts to secure its country against any external or internal cyber-threats, etc.

3. System Configuration

3.1 Overview

Singapore's Smart City configuration is distributed into a number of databases, control operations centres, and a number of applications. Since it is the beginning stage of Smart Nation Vision, a detailed framework that connects individual agencies are currently being developed. Singapore has plans to connect implementing agencies through some sort of data pipes to connect individual governmental agencies into a single data platform.

3.2 Level of physical system integration

The Smart Nation Vision comprises urban sectors (such as urban mobility, environment, healthcare, logistics, etc), supporting ecosystem such as industry and manpower, and Smart Nation Platform. Smart Nation Platform is divided into two layers: Smart Nation Operating System (SN-OS) and Communications & Sensor Network.

Communications & sensor Network is foundational infrastructure for deploying essential field facilities such as smart meters, CCTVs, flood sensors, etc. As shown in figure 17 field facilities installed around the city are linked both by wired and wireless connections to form communication and sensor network as a whole. Information gathered from the devices are then shared among agencies for appropriate responses.

Smart Nation Vision



Figure 16 Smart Nation Vision
Source: iDA Smart Nation Platform Industry Briefing, 2014

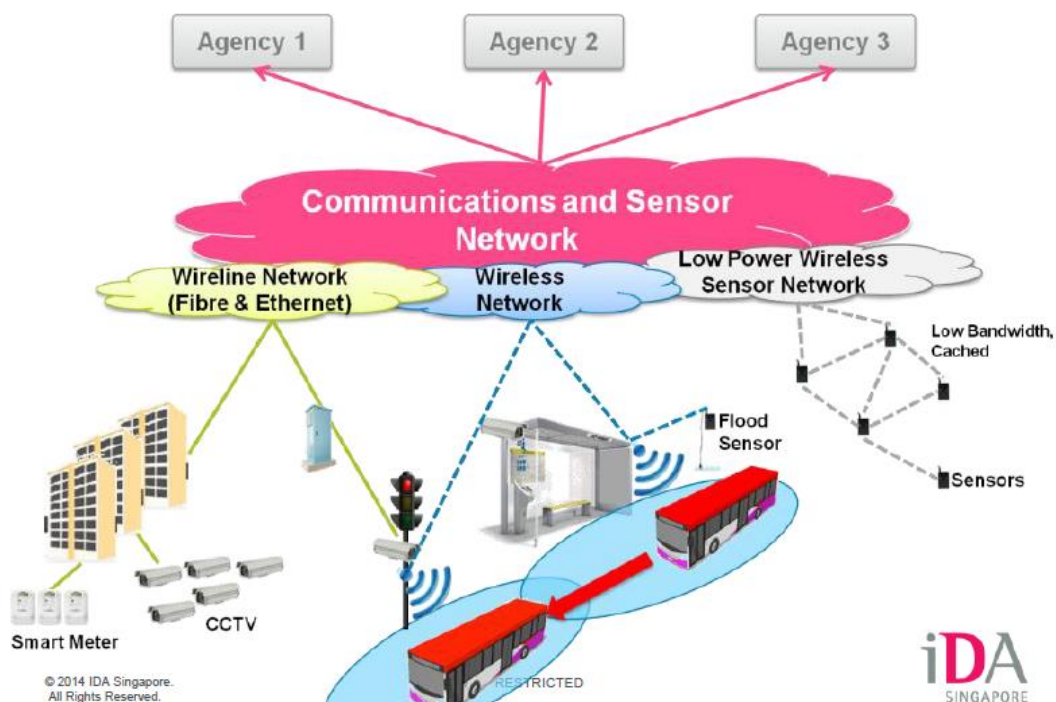


Figure 17 Communications and sensor network
Source: iDA Smart Nation Platform Industry Briefing, 2014

Smart Nation Operating System (SN-OS)

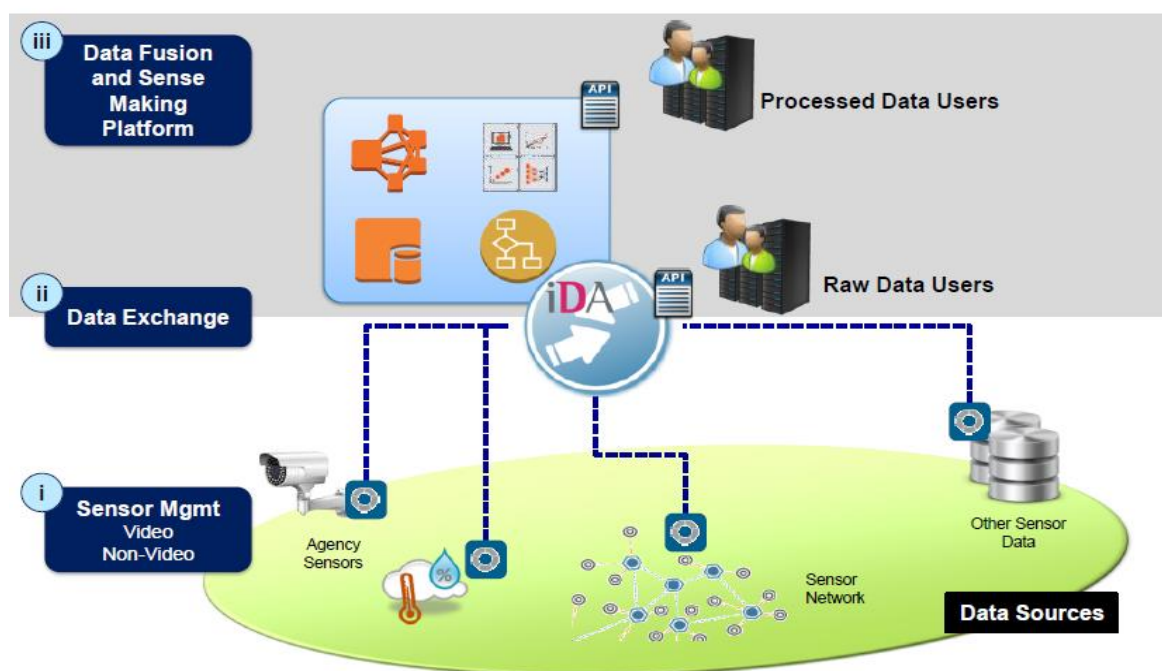


Figure 18 SN-OS platform

Source: iDA Smart Nation Platform Industry Briefing, 2014

Based on communication & sensor network, Smart Nation Operating System operates in three layers; i) sensor management, ii) data exchange, and iii) sense-making platform

i) Sensor management

Through sensor management, for both video and non-video sensors, field facilities should be regularly monitored for their well-functioning (state of charge, gateway status, sensor network performance, etc.) and be checked upon their remote controls (activation, de-activation, sensing mode, sensor-specific configuration, etc.).

ii) Data exchange

An unified platform where reliable, secure, timely data sharing is facilitated is extremely important for effective use of human and machine-centric sensor data. Within SN-OS, open standards, protocols and data security policies are established and applied to harmonize Government agencies and private enterprises in the use of data.

iii) Sense-making platform

Data are processed, integrated and analyzed for

relevant information to be delivered for end users in this sense-making platform. Figure 18 depicts SN-OS platform as a whole.

3.3 Integrated Center System

There is no wholly integrated operations centre in Singapore. The smart city structure in Singapore is somewhat discrete in a sense that individual implementing agencies manage their own operations centre.

For example, LTA has two operations centres and these OCCs operate 24/7 throughout the year to monitor traffic and to transmit collected real-time traffic information electrically.

A separate operations centre exist for SCDF, where the advanced C3 Emergency System is used to primarily perform dispatch of emergency appliances and receiving call from the public.

3.4 Field system

Smart city sector	Sub-system	Technology / field device
Transport and urban mobility	Green Link Determining system (GLIDE)	Metal wire detector loops installed below the road surface and at junctions. Pedestrians are detected through push buttons, placed at traffic signal poles.
	Expressway monitoring and advisory system, J-eyes	LTA has 1,000 surveillance cameras installed island-wide. The camera is shared at the government level. 
	E-traffic Scan	GPS device equipped on all taxis
Citizen safety and security	Community policing system	Surveillance police cameras installed mainly around HDBs
Environment	Automated water meter	Smart water meter that monitors residential water use 
	Smartbin	The ultrasonic UBi sensor which allows smart bin service has the following features and functionality:  - Operates wirelessly - Reports fill-level - Long battery life (up to 10 years) - Changeable battery - Robust weather proof 0.25kg weight - Internal antenna and SIM-cad reporting to cellular networks
Energy efficiency	Smart grid	Smart meters that are equipped with communication capabilities play an especially vital role in allowing the system to be two-way channel.
Citizen interaction	Mobile/web-based applications	All applications can be accessed by smart phones or computers

Table 2 Field devices

3.5 Communication system

Singapore has continued to make strategic

investments to deploy a trusted and intelligent Next Generation National Infocomm Infrastructure (so-called Next GEN NII). Next Gen

NII is Singapore's new digital super-highway for super connectivity as part of the iN2015 Masterplan and it has two components: first, a wired broadband network that delivers ultra-high broadband speed at homes, offices and schools, and second, a wireless broadband network offering pervasive connectivity around the nation.

Next Gen NII will offer a competitively priced broadband with speed up to 1 Gigabit per second and enables users to enjoy a richer broadband experience.

3.6 Sub-systems and functions

3.7.1 Transportation and urban mobility

The first Electronic Road Pricing Systems (ERP) was introduced in 1998 (this replaced the first road-pricing scheme in Singapore called the Area Licensing Scheme introduced in 1975) as part of its ITS system, which uses a short-radio communication system to deduct charges from smart cards attached on all vehicles. ERP attempt to match supply with car demands throughout the day and hence, the charge varies according to the traffic flow conditions and the time of the day.

ITS components are overseen by the Land Transport Authority (LTA). The development of the smart systems and operations are done by the ITS Centre (ITSC). There are two command centres within LTA: i) Intelligent Transportation System Operation Command Centre (ITS OCC) and ii) Kallang-Paya Lebar Expressway/Marino Coastal Expressway Operation Command Centre (KEP/MCE OCC). The former handles all road operations, whereas the latter is dedicated to monitoring of tunnels.



Figure 19 ITS OCC

Source: Intelligent transport systems centre, LTA, 2010

ITSC is at the core of traffic management. It manages traffic flows on roads and maintains the ITS infrastructure. The ITS infrastructure covers over 161km of expressways and road tunnel systems.



Figure 20 ERP in Singapore

Source: City climate leadership awards, Singapore climate close-up

In Singapore, key ITS components are under the

i-transport system, which is the intelligent information management system for transport initiatives. I-transport provides an integrated and unified platform where management of all ITS including traffic signal control, traffic monitoring, incident management tunnels and highway monitoring and provision of real-time traffic advisory information are centrally managed. Smart sub-systems that are managed by this system are as follows:

A. Green Link Determining (GLIDE) system

Within the ITS, all traffic signals are controlled by the Green Link DEtermining (GLIDE) system. Under the system, the green light is allocated based on real-time traffic demands and traffic signals at neighbouring junctions along major corridors are linked, minimizing the drivers' stops while they travel from one junction to another (this is known as a green wave). Presence of pedestrians are detected through push button that they press at crossings.

GLIDE automatically detects the traffic flow, traffic light faults and pedestrians and for such system thin metal wire detector loops are installed below the road surface and before signal junctions.

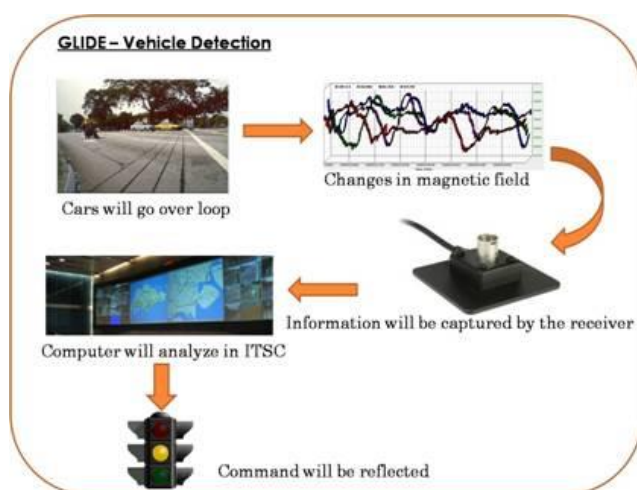


Figure 21 GLIDE vehicle detection
Source: SMU School of Information System



Figure 22 GLIDE pedestrian detection
Source: SMU School of Information System

B. Expressway monitoring & advisory system (EMAS)

EMS monitors traffic on expressways using surveillance cameras and alerts motorists of any traffic incidents and make sure swift response is made to these incidents. EMAS Arterial capabilities have been fitted to 10 major arterial road corridors in early 2014, helping to manage traffic and guiding drivers more effectively.

C. J-Eyes

Surveillance cameras installed on special poles, street lamp posts and traffic light poles at road junctions monitor traffic conditions and to send video images to the traffic control centre. The information gathered are monitored by the Operations Executives who decide on appropriate implement actions when any problems occur.



Figure 23 J-Eyes surveillance camera
Source: ITA website

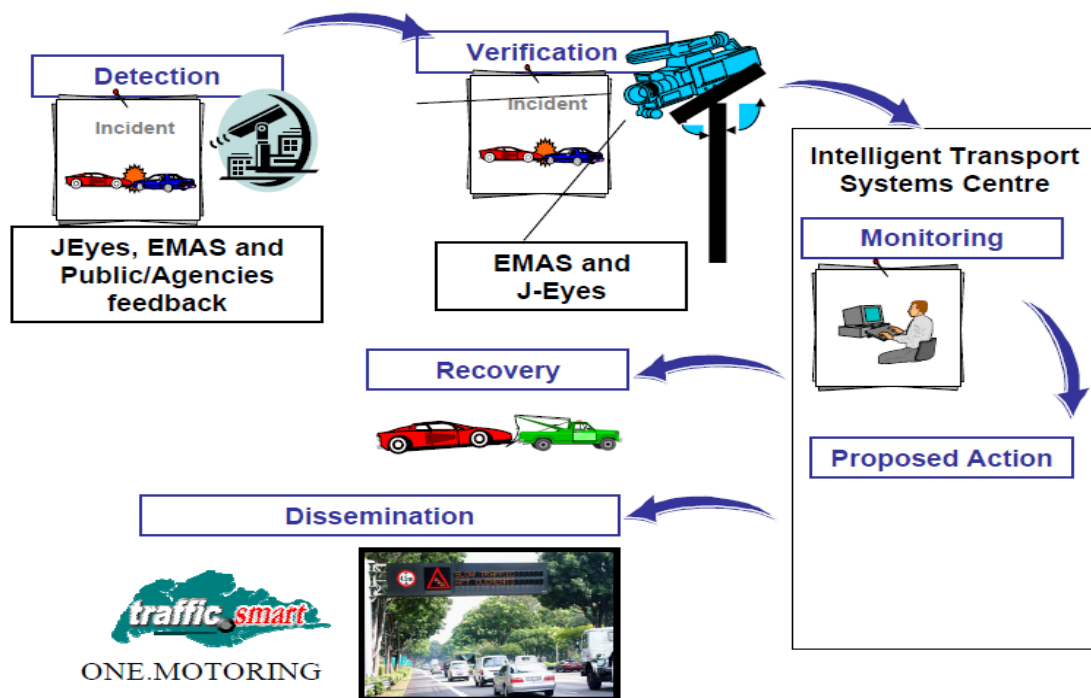


Figure 24 EMAS workflow
Source: SMU School of Information System

D. e-TrafficScan

LTA works in cooperation with city taxi companies. All taxi vehicles in the city are equipped with the GPS that tracks their locations and speed as they probe on the road network. Taxis act as a form of moving sensor and data

collected are returned to drivers to provide travel information on both expressways and arterial roads, improving the time-efficiency of their journey route. The information can be found on the One Motoring Portal, along with other ITS such as EMAS and GLIDE.

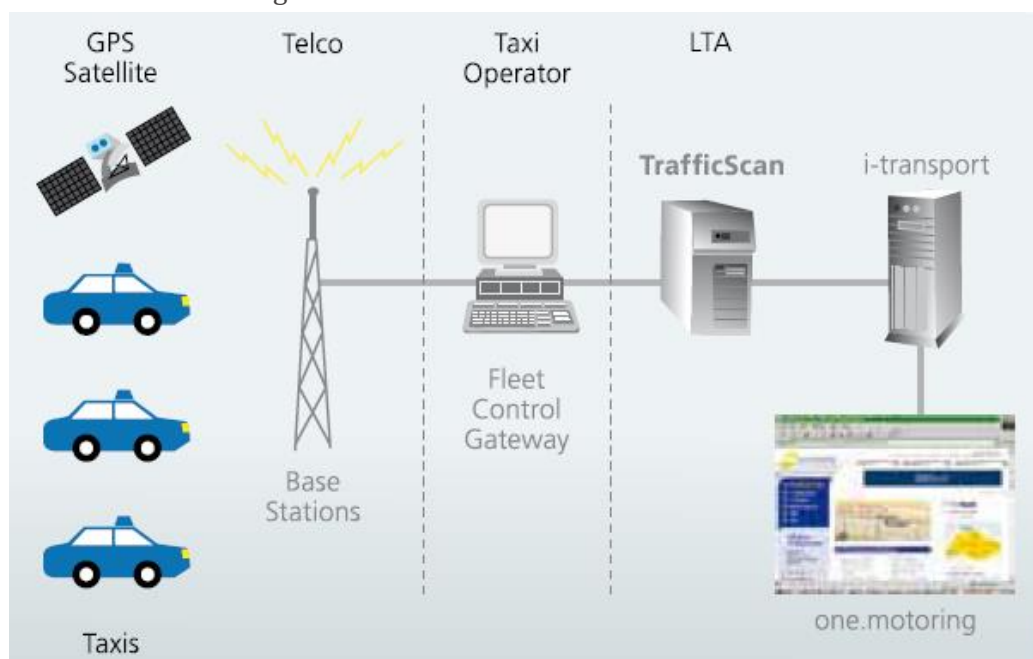


Figure 25 Information flow in TrafficScan
Source: TrafficScan-Bringing Real-time Travel Information to Motorists, CHIN Kian Keong and LEE Chin Wai (2009)

E. Traffic message channel (TMC)

The traffic message channel is a standard for delivering real-time traffic information to drivers

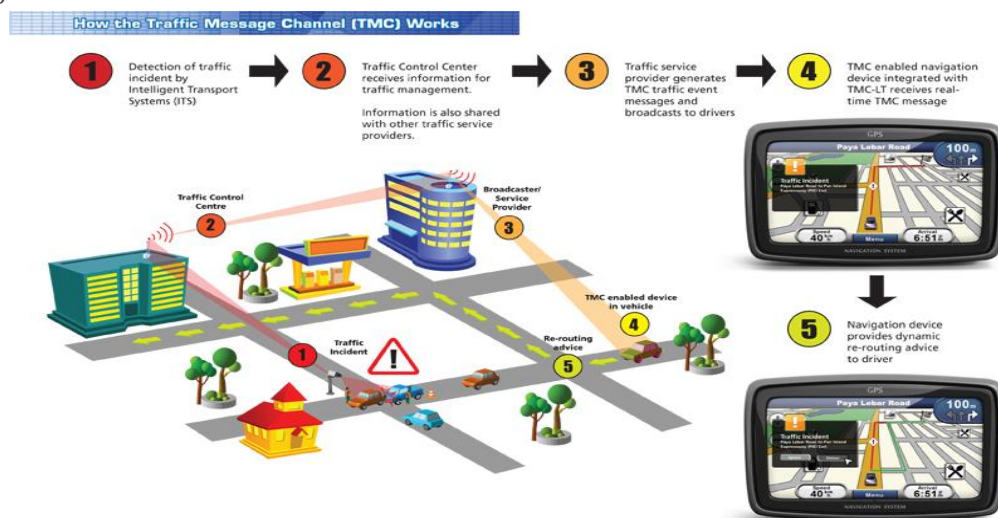


Figure 26 How TMC works

Source: Land Transport Authority official website

3.7.2 Safety and citizen security

The Advanced Systems Programme Centre within the Defence Science & Technology Agency of Singaporean Government develops, integrates communication systems, sensor solutions and guided weapons to meet Singapore's defence needs and operation challenge.

About 40,000 police cameras have been installed in over 7,000 Housing Development Board (HDB) blocks and multi-storey carparks (MSCPs) as of September 2015, as a key component of the Community Policing System. Police Force expect all 10,000 HDB residential blocks and MSCP to be installed with these cameras by December 2016. These cameras are not monitored at a real-time but it records footages to assist solving crimes.

In early 2015, it was announced that officers from Singapore's Bukit Merah West Neighbourhood Police Centre (NPC) would begin trials of body worn cameras. The cameras are designed to be worn visibly and also show an indicator when they are recording. Singapore Police Force announced that the devices will aim to be in use at all 35 NPCs by June 2016.

Amid the need to effectively manage existing

through TMC-compliant devices. TMC message that carries location code and an event code is transmitted to the device in vehicle.

thousands of sensors, unified surveillance platform (USP) developed within the Singaporean Police Force Police Technology Department.

3.7.3 Emergency and response

Incidents are detected by various smart sensors that are deployed around the city. The incidents are verified and assessed through appropriate operations control centre leading to one of the following things: activation of EMAS response team if this is a road incident, transfer of information to relevant agencies such as Singapore Police Force or SCDF, and/or the news is disseminated to public through signboards, radios, websites, or social networks.

3.7.4 Environment

An efficient and smart environmental initiatives are incredibly important for Singapore, given its limited land area and dense population. The National Environmental Agency (NEA) plans, develops and manages systems relating to (but not limited to) pollution, solid waste and energy.

NEWater is high-grade reclaimed water produced from treated used water that is further purified

to become a safe drinking water. In 2010, a largest NEWater plant was built and now this meet up to 30% of the nation's current water demands. It is expected that NEWater can meet up to 55% of the demand by 2060.

The smart monitoring system that uses multi-functional water sensors allow water loss, or non-revenue water, to be kept at 4.6% in Singapore, which is one of the lowest levels in the world.

PUB has also developed a new technology called Variable Salinity Plant. This technology is a two-in-one plant that can treat both freshwater or seawater to produce drinking water. This technique is anticipated to enhance the viability of marginal water catchments to increase the water supply in Singapore at low cost.

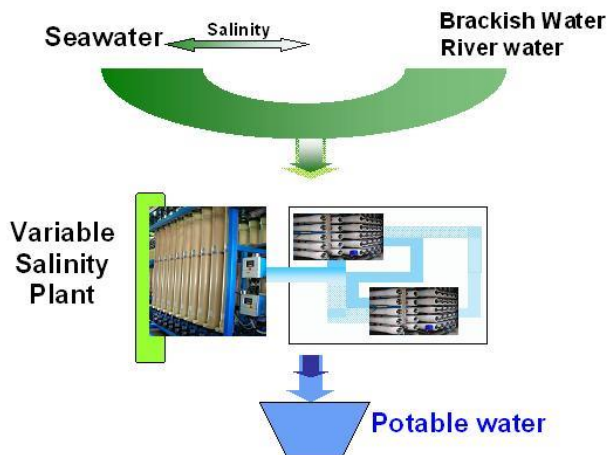


Figure 27 Variable Salinity Plant System
Source: PUB official website

In terms of real-time monitoring of water distribution system, smart monitoring system is in place. Singapore uses a platform known as WaterWise. Understanding the water distribution improves the efficiency of the network and general operation. There is a 25-node wireless sensor network deployed in the city of Singapore and WaterWise is linked to PUB's SCADA system to exchange sensor data and to operate remotely. This platform, through the following process, works together to bring about non-revenue

water reduction, improvement in planning confidence, improvement in response management, etc.

Moving on to waste, Singapore's current waste management system functions as follows:

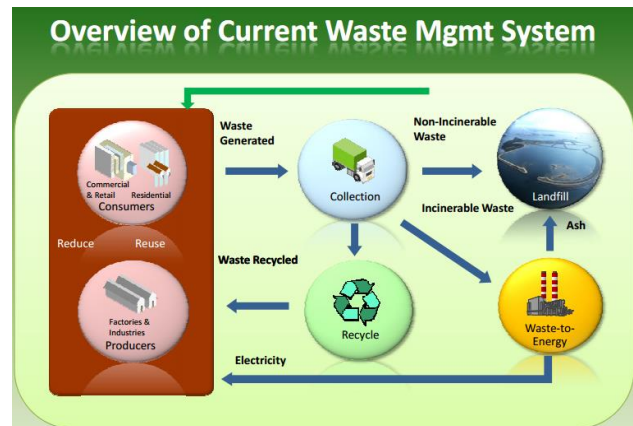


Figure 28 Waste management process

The smart bin uses the 'ultrasonic UBi sensor'. This is a plug and play device that reports real-time fill-level data to the SmartBin live portal. The sensor and route planning software allows simple and smart waste and recycling collection through following process:

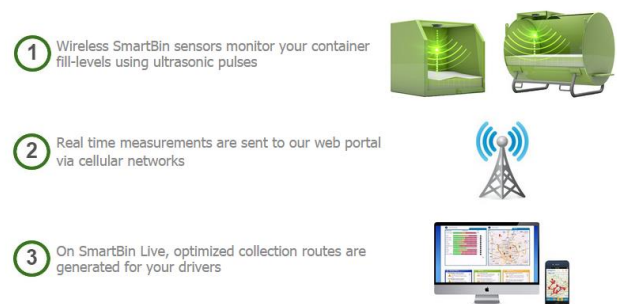


Figure 29 Smart waste bin process

3.7.5 Energy efficiency

Intelligent Energy System (IES), launched in 2009, is a smart grid system that provides real-time information on how electricity is used. IES attempts to improve efficiency of network operations and facilitate active participation among consumers by connecting intelligent homes, vehicles, communities, electricity network sensors and sources of green generation.

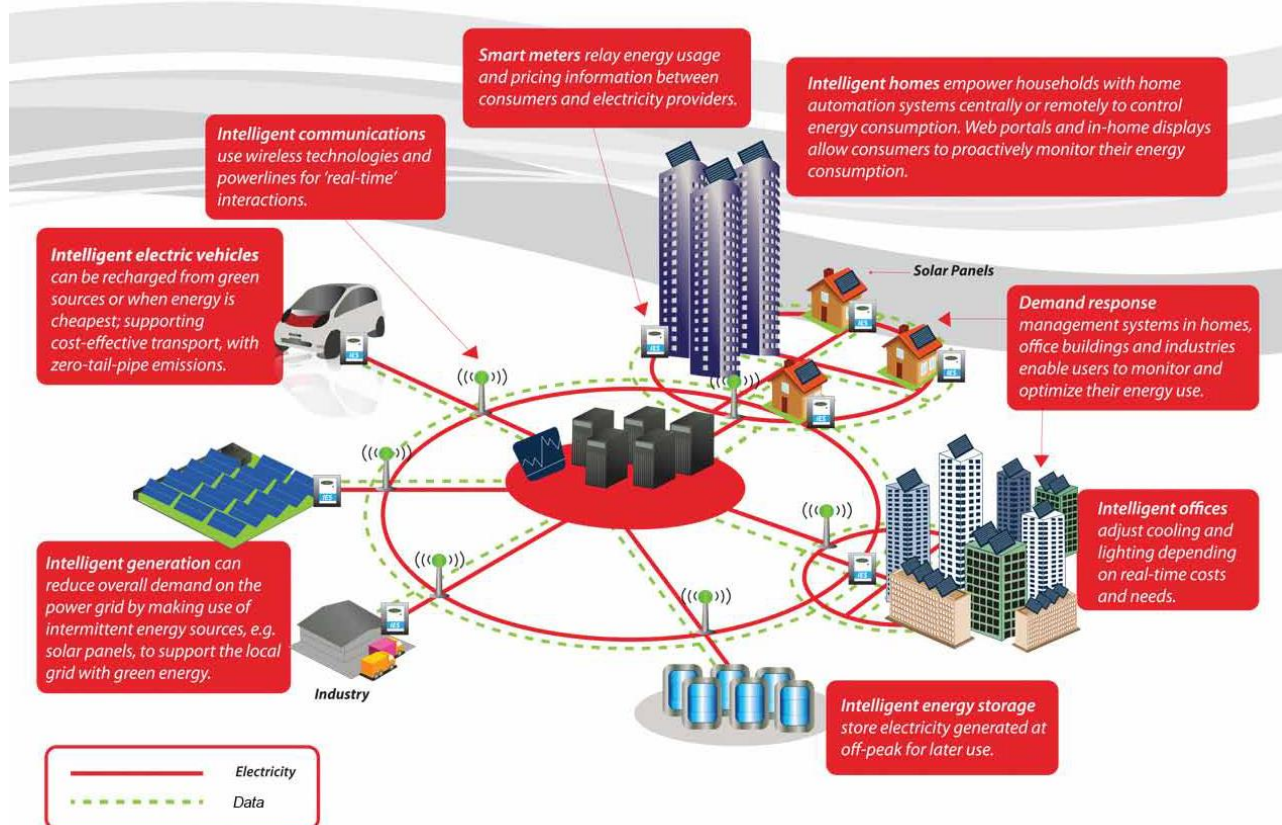


Figure 30 Nationwide Intelligent Energy System (IES) (source: NEI)

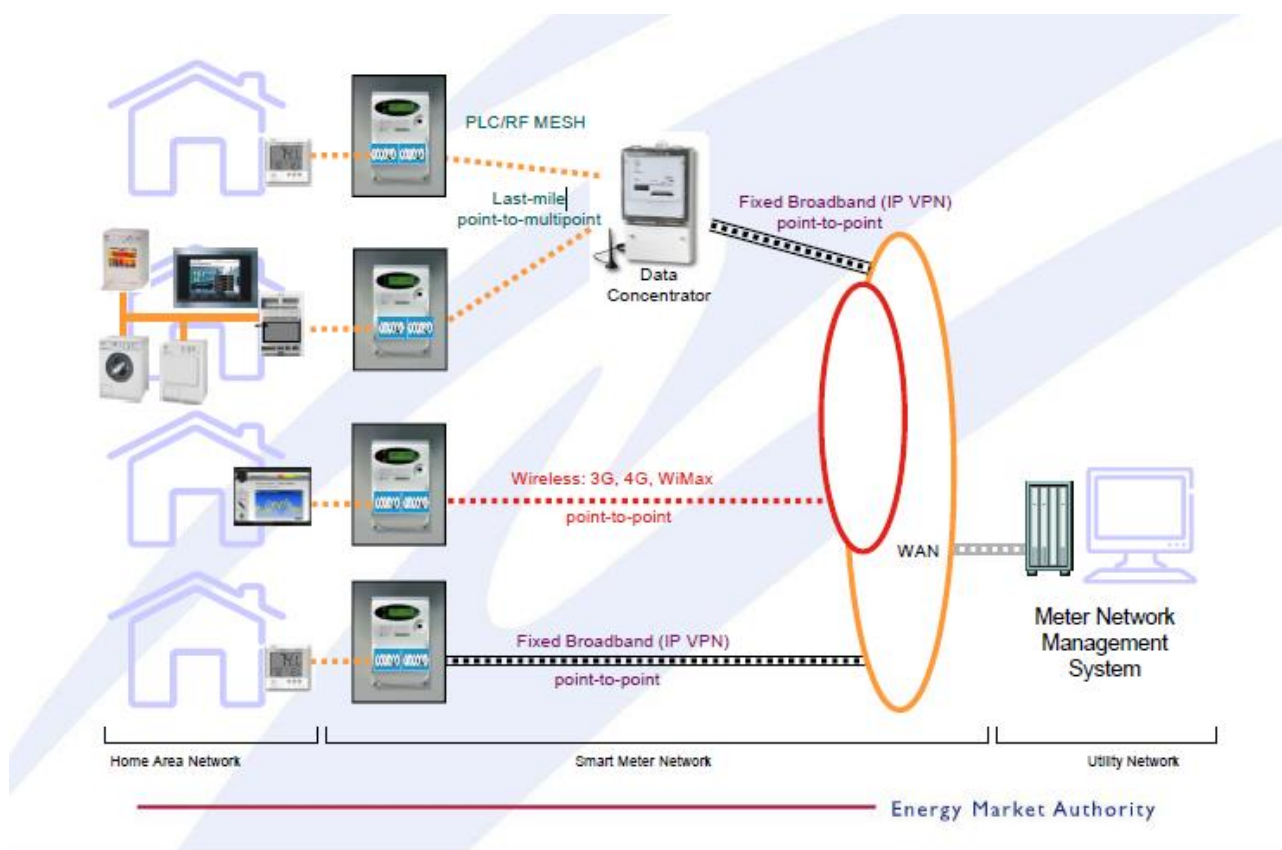


Figure 31 Wire/wireless meter network management system

Singapore's IES Pilot implemented in two phases. The phase 1 that began in 2010 focused on

developing the enabling infrastructure and the testing of smart meters that are equipped with communication capabilities. This initial phase established two-way data communication. Phase 2 began in 2012 and this evaluated customer application which ride on advance metering infrastructure. The main focus of phase 2 was to engage the customers through applications trials. Smart meters that are equipped with communication capabilities play an especially vital role in allowing the system to be two-way channel. They provide both consumers and the grid operator with information on how much electricity they are using.

Other measures to be energy efficient include smart streetlight, which is designed to detect motion and adjust automatically, as well as sending signal to city officials when faulty is anticipated to be fully implemented. Smart technologies are expected to work together to reduce energy wastage while promoting a sustainable and greener urban environment.

3.7.6 Citizen interaction

In line with the eGov Master plans over the past three decades, various e-Government programmes have been or will be introduced to fit its Smart Nation Visions. The programmes are usually in the form of smart phone applications to serve all three groups: Citizens, Business and Government. Government agencies are also encouraged to develop their own applications, to meet different needs of the citizens.

4. Organizational Structure

4.1 Governance model

Implementing agencies operate in a discrete manner in Singapore. Even under the Smart Nation initiative, there seems to be no intention to have a physically integrated Operations Centre.

There are number of different command centres that are managed by individual agencies and these agencies only come together at the time of emergency.

Although interest for IOCC is not there, Singaporean Government sees the need to develop an integrated data sharing platform, where all agencies can access commonly shared data collected from shared smart sensor network. It is argued that information and sensitive data are more secure at the senior level under the distributed command centre system. Gathering the very senior levels of each agency only during large-scale emergencies was observed to be safe, efficient and effective.

To prevent any drawbacks caused by the lack of communication between the Government agencies, parts of Smart Nation initiative are to encourage active cooperation, and to focus on cross-cutting technology, infrastructure and policies.

The Smart Nation Programme Office that lies directly under the Prime Minister's Office of Singapore has been set up to act as a coordinating body.

4.2 Information control, ownership and sharing

Smart sensors within the communication and sensor network are shared, allowing different agencies to make different uses of collected information. For example, CCTVs deployed can collect information on traffic flow. Motoring, detect any road incidents for prompt response, or act as surveillance camera to enhance citizen urban security.

4.3 Protocols and procedures of decision making between agencies

Statutory bodies, also can be understood as implementing agencies such as LTA, under the

ministries of the Singapore are more or less equal in terms of their level of authority. At the time of the emergency, when a national-level issue is raised, decision-making and commands are given (usually) by either the Ministry of Home Affairs or the country Military force.

4.4 Cost system

All funding related to Smart Nation Vision are provided by the Singaporean Government. So far, no external funding was exploited. The Government has not allocated specific budget for the Smart Nation Vision, but the cost of initiatives are embedded in each agencies. Just like any other projects, if an agency is to set off a new smart city initiative, a funding proposal is required to be submitted to the Ministry of Finance for an assessment.

5. Monitoring and Control

5.1 Quantitative and qualitative measures for benefit items

Governmental agencies such as LTA, SPF, URA, SCDF, PUB, etc. have their own Key Performance Indicators (KPI) that are reviewed periodically. Although specific KPIs are not open to the general public, Singapore Government regularly publishes Singapore Public Sector Outcomes Review, known as SPOR. The biennial SPOR, which is open for public, takes stock of how Singapore has undertaken in key areas of national interest. Coordinated by the Ministry of Finance, with inputs from all Ministries, SPOR divided into five chapters, giving overview of the followings¹:

- 1) A nation of opportunity
 - i) Quality economic growth
 - ii) Work and education opportunities

¹ Please see attached annex to find indicators for each chapters

- 2) A caring and cohesive society
 - i) Population policies
 - ii) Affordable healthcare
 - iii) Aging population
 - iv) Community
- 3) A city to call home
 - i) Public housing
 - ii) Social spaces
 - iii) Environment
- 4) A safe, secure and credible Singapore
 - i) Nation security
 - ii) Home safety
- 5) An effective and trusted Government
 - i) Governance
 - ii) Public service
 - iii) Fiscal system

SPOR is an overview of the city-nation. Individual implementing agencies seek to measure their own performances in both quantitative and qualitative terms. Basic statistical figures are summarized in the annual reports. For example, SCDF will have basic statistics on the number of fire responses. In 2013, SCDF responded to more than 4,000 fires, which is a decrease of 7.8% of cases 2012. 2013 recorded the lowest annual number in 20 years (Figure 32).

Similarly, benefits of surveillance cameras may be measured through the number of crime cases that it has assisted in solving, and ultimately, reduce the urban crime rate. Several Singaporean newspaper articles revealed that cameras installed at Housing and Development Boards blocks since 2012 has helped to solve more than 430 cases and provided crucial information for 890 crime investigation cases.

It is interesting to note that unlike some other countries, benefits of smart city services are not commonly quantified in monetary terms. Such quantification manner is not prevalent and agencies do not tend to be interested in such statistical figures. Instead, more focus is on improving the current services and satisfaction level of the general public.

E-government satisfaction rate: Through the

regular e-Government Customer Perception Surveys, Singaporeans have shown a high level of satisfaction with e-Government services. IDA's report on iN2015 (2010) revealed that 9 in 10 citizens are satisfied with the quality of e-Government services and will recommend it to others.

LTA conducts frequent surveys to gather data on whether their ITS systems have benefitted the motorists or not. A number of different surveys are conducted in packs (for specific topics) and an example of a brief survey that is attached in ITSC brochure is as below:

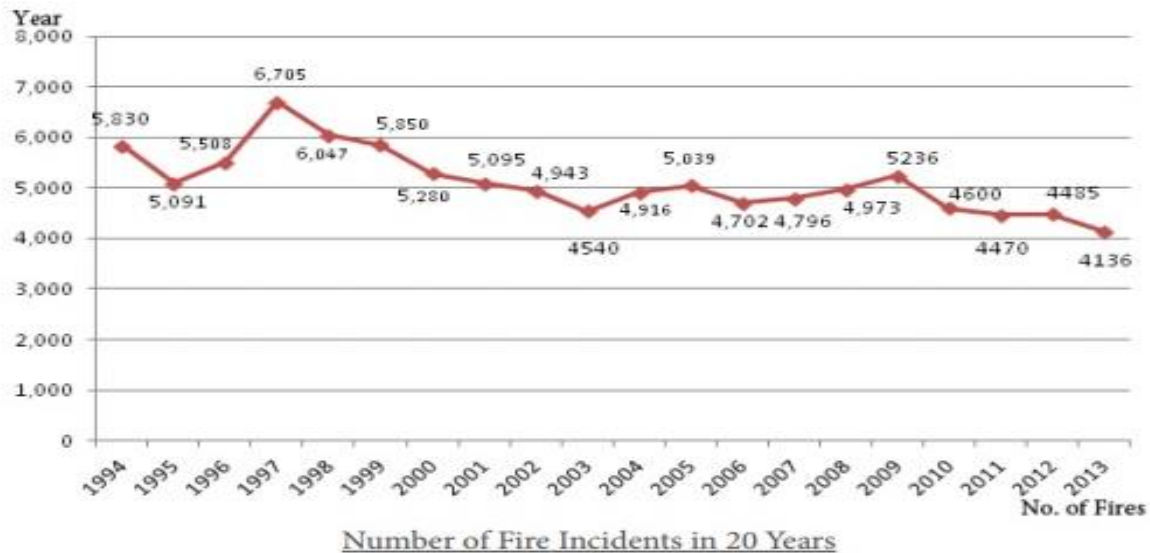


Figure 32 Number of fire incidents in Singapore (20 years) (Source: SCDF annual report)

ITSC Survey Form

We would like to serve you better. Please let us know how you find our services. Thank you.

Name: _____ Contact Number: _____

Electronic Message Signs

i) Visibility of message

ii) Clarity of message

iii) Usefulness of message

Excellent	Very Good	Good	Fair	Poor	Very Poor
6	5	4	3	2	1
6	5	4	3	2	1
6	5	4	3	2	1

Traffic Lights

i) Visibility of traffic lights

ii) Reliability of traffic lights
(e.g. very few breakdowns)

6	5	4	3	2	1
6	5	4	3	2	1

Other comments:

Figure 33 ITSC Survey form (Source: ITSC brochure)

6. Lessons Learned

It is difficult to draw specific implications of the Singapore's Smart Nation Vision, since it was only launched at the very end of 2014.

However, some lessons may be learned from their cautious method of smart city construction. For example, Singapore seem to make good use of pilot projects before implementing smart service nationwide. This allows them to test factors such as whether the service provided is useful for citizens, the actual cost at implementation, and also reduces risk of installing inappropriate smart system across the entire nation. Singapore has particular advantage in terms of carrying out pilot projects in selected region, partly due to its extensive ownership of public housings, where approximately 80% of the resident population live, making it easier for them to try out services like in-house displays (see page 15).

Singapore's attempt for smart integration may also be a good reference point for other future smart cities around the world. So far, Singapore's implementing agencies have been working very discretely and independently of each other (as explained in chapter 4). New smart solutions that were accompanied by advancement in technology have been designed, monitored and managed by each agency. However, as smart solutions expanded in its scopes and as services began to overlap between various fields of the city (across various agencies), the needs for common platform to maximize the utilization of smart devices, effectiveness of data sharing, and to minimize cost became clear. Now Singapore, under the Smart Nation initiative, is cautiously striving to search for optimum method of integration. This demonstrates that perhaps, without common platform to share information across different sectors of the city, maximization of effectiveness in managing the smart services may be challenging. Understanding Singapore's case provides a good reminder for other cities to ponder about the necessity of integration within the smart city.

Although it is still at its early stage, Singapore's smart city experience is expected to provide a

valuable lesson for all cities around the world in the future.

7. Conclusions

Singapore's case study provides an interesting example of a nation's approach towards being a Smart Nation. Since there are no other cases where the entire country is being transformed under careful plan of the central Government, Singapore is believed to be unique in comparison to other smart cities initiatives around the world.

Based on this study, Singapore's future success as a Smart Nation may depend on a number of factors. First is the Government's control over the Smart Nation Vision. Currently, Smart Nation initiatives are completely funded by the Singaporean Government with no external source of funding from private firms. It is still uncertain whether or not this will lead to more effective, fast, and efficient implementation of smart systems with no external motivations, and whether all high-costing initiatives can be sustained under such method of funding. Second factor is regarding the manner of integration among implementing agencies. There is yet no consensus in how to integrate these agencies and it is still being developed, but so far, the underlying idea is to avoid physically integrated platform but to agree on rules and regulations for data integration. Singaporean Government only see the need to develop an integrated data sharing platform, where all agencies can access commonly shared information collected from shared smart sensor network. An interest for Integrated Operation and Command Centre (IOCC) is not there and in fact, this is perceived to have higher risks due to variations in the sensitivity of data. Utilizing data is key to the success of any smart city and hence, how they manage data integration platform would become the deciding factor for their success.

Although it is difficult to make any clear-cut judgements as it is still in its infancy, expectations for Singapore to become a world-leading smart city is high.

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Interviewed stakeholders

1. Representatives of the Smart Nation Programme Office, Prime Minister's Office, Republic of Singapore
2. Representatives of the Land Transport Authority, Republic of Singapore

Annex B. Singapore Public Sector Outcomes (SPOR) indicators

- 1) A Nation of Opportunity: child education, incomes, business productivity
 - Real Gross Domestic Product Growth Rates (%)
 - Resident unemployment rate (annual average) (%)
 - Labour productivity growth (based on GDP at 2010 prices) (%)
 - Foreign Direct Investment (\$bil)
 - Changes in Singapore's Consumer Price Index (%)
 - Real monthly household income from work per household member among citizen employed households
 - Employment rate for citizens aged 25-64 (%)
 - Resident labour force with at least post-secondary qualifications (%)
 - Overall training participation rate (percentage of resident labour force aged 15-64) (%)
 - Gini coefficient based on household income from work (incl employer CPF per household member among resident employed households)
- 2) A Caring and Cohesive Society: healthcare, retirement, caring community
 - Composition of total population (million)
 - Total fertility rate (per female)
 - Cohort divorce rate (%)
 - Life expectancy of residents at birth (years)
 - Average coverage of class B2.C bills by medisave and medishield (%)
 - Employment rate for citizens aged 55-64(%)
 - Active CPF members who are able to meet the minimum sum in cash and property at age 55 (%)
 - National volunteerism rate (%)
 - Charitable giving to IPCs
 - Number of households assisted under ComCare
- 3) A City to Call Home: public housing, public transport, social spaces
 - Weighted average debt servicing ratio (DSR) for first-timer applications buying new flats in non-mature estates (%)
 - Home ownership among resident HDB households
 - Customer satisfaction survey for public transport system (%)
 - No. of delays more than 5 minutes per 100,000 train-km on MRT/LRT network
 - Singaporeans generally satisfied with living environment
 - Domestic waste disposed per capita (kg per day)
 - Domestic water consumption per capita (litres per day)
- 4) A safe, Secure and Credible Singapore: national service, home safety, international partnership
 - Overall crime rate (per 100,000 population)
 - Ex-offenders' recidivism rate (%)
- 5) An Effective and Trusted Government
 - Percentage rank of the quality of governance (worldwide)
 - Average overall budget balance over the business cycle as a percentage of GDP
 - Net benefits (transfers less taxes) as percentage of household income (%)

ANNEX C – Service spectrum

Key smart city service spectrum		Smart city functions and medium				
Service domain	Service system	Monitoring and data collection	Control	Data processing and information production	Information communication with citizens	Information sharing with agencies*
		Signal controller, image detector, BIS, CCTV, web portal...		Patten analysis, route optimization...	VMS, internet, mobile, call center, open-API, broadcasting...	Information platform (control, ownership and sharing)...
Transportation and urban mobility	Bus Information and management	4	4	4	4	4
	Parking information	4	4	4	4	4
	Traffic information	4	4	4	4	4
	Adaptive traffic signal control	4	4	4	4	3
	Traffic violation enforcement	4	4	4	4	3
	Electronic road pricing	4	4	4	4	3
	E-traffic scan via taxi	4	4	4	4	3
Safety and citizen security	Intelligent crime prevention	4	4	4	4	3
	Electronic police center	4	4	4	4	3
	Community policing	4	4	4	4	3
Emergency and response	Intelligent emergency management	4	4	4	4	4
	Emergency medical service	4	4	4	4	4
	Road incident management	4	4	4	4	4
Environment	Smart waste bin	4	4	4	3	3
	Automated water meter	4	4	4	3	3
Energy efficiency	Intelligent energy management and smart grid	4	4	4	4	3
	Wire/wireless meter network management	4	4	4	4	3
Citizen interaction and communication	E-government portals	4	4	4	4	4
	Various mobile applications	4	4	4	4	4

* **Agencies:** Police officers and petrol cars, community groups, fire stations, military bases, related departments (road, public transport, river management, water management, environmental preservation...) etc.

* This table summarizes the key smart city services and systems investigated in this research. The above list does not represent the full spectrum of the city's services and systems.

* **Performance level:**

4 – Advanced

3 – Moderate

2 – Basic

1 – Absent

T – To be introduced in the future

