



## SINGAPORE

# Taking care of the big picture

## Innovative approaches to future urban solutions

*Since gaining independence in 1965, Singapore's urban landscape has gone through major changes in the past four decades. In the 1960s, the city-state was beset by high unemployment, an overcrowded city centre, and a shortage of proper housing and adequate infrastructure. Singapore has since rapidly developed into a dynamic and globally important economy with a prominent international profile in banking, electronics, biomedical engineering and advanced science and technological innovation.*



**T**oday Singapore is a thriving business and financial hub with a vibrant mix of retail and entertainment activities. Residents are housed in high quality homes located in the heart of the city as well as self-sufficient new towns supported by a wide range of public services and ample greenery. Building on a record of triumph over adversity, Singapore's government is committed to investing in research and development (R&D) to secure a prosperous and sustainable future for the country.

None of Singapore's successes have occurred by chance. With a land area of around 715 square kilometres and a population of over five million, Singapore is one of the world's smallest and most densely populated nations. However, its capacity for innovation and growth is equal to that of countries several times its size. Its unique circumstances and limitations in land and natural resources

demand judicious, comprehensive and long-term planning.

Singapore's public authorities face unique challenges in making the city-state more sustainable. In the early days, Singapore's problems were complex and hard to tackle, ranging from inadequate urban infrastructure systems to the proliferation of slums and poor living conditions. While Singapore's resource and size constraints may be perceived as limiting at first, they have served as the impetus for planners to pioneer resource-efficient technologies.

Public agencies in Singapore must ensure that there is sufficient land to support an entire spectrum of activities with multiple and competing land needs. Beyond providing homes for residents, sufficient land and infrastructure has to be provided to support the country's financial sector, shipping and air hubs, industries, transport facilities, utilities and offices. Space is



also set aside for parks and green spaces, reservoirs, cultural and heritage conservation, and community and recreational spaces, as well as for security needs.

With the use of innovative urban planning strategies, technologies, and governance models to ensure the timely implementation of forward-thinking development plans, Singapore has proven that with the right vision and resources, cities can become 'smart' and sustainable. Singapore is well positioned to develop solutions to both solve its own problems as well as those of other cities facing similar urban challenges, setting the stage for the country to become a global hub for sustainable development solutions into the next four decades and beyond.

### Liveability and quality of life

As a testament to Singapore's success in creating a thriving and liveable urban metropolis, the city-state is ranked first for city infrastructure in Mercer's worldwide 2012 Quality of Living survey. According to Siemens' Asian Green City Index released in 2011, Singapore was ranked top in the region when measured against a range of sustainability criteria such as carbon and energy emissions, land use and buildings, water, sanitation, air quality and environmental governance. To further affirm the Republic's impressive progress, the Economist Intelligence Unit placed Singapore sixth out of 80 countries in their 2013 Quality-of-Life Index, describing it as one of the best nations in which to be born.

In recent years, investment and development have further enhanced Singapore's attractiveness as a city in which to live, work and play. Recreation and leisure options have increased, with the world-class performance venue "Esplanade – Theatres on the Bay" showcasing a wide range of international and local arts and cultural performances, as well as the ambitious "Gardens by the Bay" creating a green leisure and entertainment space in the heart of the city. Additionally, Singapore boasts some 5,700 hectares of parks and nature reserves, which, together with almost 200 kilometres of 'park connectors' that link up various parts of the island, give its residents the feeling of dwelling within a lush, green environment.

### An impeccable plan

Backed by a progressive leadership, Singapore is committed to continuing its efforts to create resource-efficient policies and technologies through well-placed investments and forward-thinking collaborations. These will help to achieve both economic development and environmental sustainability while improving the country's overall quality of life. Singapore strives to be a 'living laboratory', a place to test new concepts and develop and commercialize cutting-edge urban approaches and solutions to increasing urban challenges. One unique quality of Singapore is the ability of public and private sector agencies working together in close partnership to catalyse the growth of the entire R&D industry. This 'whole-of-Singapore' approach offers

industry players the opportunity to work with a range of research performers, each with a spectrum of research capabilities.

Singapore's R&D efforts began in 1991, when the government formed the National Science and Technology Board to frame the first five-year national technology plan for 1991 to 1995 and prepare Singapore to advance its economy and thrive in the knowledge era. With an allocated budget of S\$2 billion, the board was tasked with developing Singapore into a R&D hub in selected fields of science and technology in order to boost competitiveness in industry and the service sector.

By the second five-year technology plan, from 1996 to 2000, investment in R&D doubled to S\$4 billion. Recognizing the tremendous growth in the area of biomedical sciences, Singapore launched the Biomedical Sciences Initiative in 2000 to establish biomedical sciences as one of the key pillars of the Singaporean economy, alongside the Electronics, Engineering and Chemicals Initiative.

In 2002, the National Science and Technology Board was renamed the Agency for Science, Technology and Research (A\*STAR). Leading and driving scientific research in the biomedical sciences, and the physical sciences and engineering, A\*STAR seeks to foster talent to create economic impact that will bring about social benefits for the whole country. With the biomedical sciences identified as a new growth area in Singapore, government investments in

research continued to rise; with S\$6 billion budgeted for 2001 to 2005, and a further S\$13.9 billion in the 2006 to 2010 science and technology plan.

The steadily increasing national research budget acknowledges the importance of science, technology and research for the growth and development of Singapore. From 2011 to 2015, the Singaporean government is committed to spending another S\$16 billion in research, innovation and enterprise to establish Singapore as a world-class R&D hub through the development of human, intellectual and industrial capital. Established in 2006, the National Research Foundation (NRF) coordinates the research of different entities within the national framework to transform Singapore into a knowledge-intensive, innovative and entrepreneurial economy.

### Preparing for tomorrow's demands

Singapore has set itself the goal of remaining as one of the world's most liveable cities — clean, green, safe and efficient for both residents and visitors — while sustaining economic and population growth. Over the next 15 to 20 years, Singapore has to tackle key economic, manpower and demographic issues such as a declining birth rate, an increasing elderly population and the maintenance of a sufficient labour force, as well as the need for high-value-added and productivity-driven growth. These issues are complex and affect both the present population and the next generation.

To enable Singapore to meet its long-term economic and demographic needs and create a distinctive, attractive and vibrant city, the government has to act with foresight in developing competent strategies and deploying innovative solutions. The Urban Redevelopment Authority (URA), Singapore's national land use planning and conservation authority, adopts a forward-looking, long-term and flexible strategic planning

approach to meet future developmental changes and challenges that may arise. Such planning is carried out in close partnership with other stakeholder agencies and includes the provision of different housing types and locations, space to grow businesses, and attractive and accessible recreational amenities, in addition to a comprehensive and efficient road and rail system to meet transport needs.

Comprehensive land-use planning and the coordination of the supply of state land for sale allow public agencies to steer development to meet Singapore's business, housing and leisure needs. At the same time, several major organizations, through coordination by the NRF, are actively pursuing inventive urban solutions to secure steady economic growth and a good living environment for the people of Singapore. While

this may seem like a formidable challenge, Singapore is certainly well prepared, riding on the strengths of its world-class research institutes, universities and government agencies.

### Ensuring a sustainable water supply

Singapore's unique water-resource environment requires innovative water management solutions. NEWater — an innovation developed in

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### Urban Redevelopment Authority

## Innovative urban solutions for sustainable development

The Urban Redevelopment Authority (URA) is Singapore's national land use planning and conservation authority whose mission is to make Singapore a great city in which to live, work and play. The URA strives to create a vibrant and sustainable city of distinction by planning and facilitating Singapore's physical development in partnership with stakeholder agencies and the community.

As a facilitator and regulator of development, the URA works with partners to shape the physical environment of Singapore through planning new growth areas and residential areas to be more sustainable and liveable, as well as exploring how to adapt innovative strategies and solutions for existing developments. Hence, R&D efforts are targeted towards innovative urban solutions that will enhance the quality of the living environment, the efficiency in infrastructure, and the optimization of space.

Together with other Singaporean government agencies, the URA partners with local and foreign academic institutions on research that would aid in its land use planning efforts. The current URA R&D programme, funded by the Ministry of National Development, looks at various aspects of sustainable high-density living.

Going forward, the URA, JTC Corporation and the Housing & Development Board, together with other participating agencies, are supporting the Ministry of National Development and the National Research Foundation on the National Innovation Challenge (NIC) on Land and Liveability. This integrated R&D effort aims to develop new solutions to support an economically vibrant, highly liveable and resilient city of the future with land capacity for sustained growth.

The funding allocation for the NIC is S\$135 million for the first tranche (2013-2018) to support high-impact research and demonstration projects under two interrelated thrusts: to create new space cost-effectively, and to optimize the use of space while keeping Singapore liveable. Potential projects include R&D that enables building underground or developing floating structures for utilities, and programmes to increase environmental quality and comfort, connectivity and accessibility to services, employment and amenities, as well as to optimize the provision of urban services. The NIC will also support R&D on enabling information and communications technologies (ICT) and platforms embedded with capabilities of intelligence gathering, analytics, modelling and simulation that could support the two thrusts.



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The URA is committed to making Singapore a beautiful, sustainable and liveable urban space.

To ensure the effective translation of research into practical solutions, the NIC will involve close collaboration across Singapore's infrastructure and development agencies, researchers and industry. As Singapore continues to develop new towns and growth areas, its agencies plan to test-bed and deploy promising solutions developed through the Land and Liveability NIC to leverage on R&D to provide sustained capacity and options for future generations.



[www.ura.gov.sg](http://www.ura.gov.sg)

Singapore for the production of ultra-clean, high-grade reclaimed water — is one such example. PUB, Singapore's national water agency, takes a leading role in facilitating the country's water R&D efforts and coordinates the projects through the Environment & Water Industry Programme Office (EWI). The EWI, established in 2006, is an inter-agency body that includes the Economic Development Board, International Enterprise

Singapore and the enterprise development agency SPRING Singapore, as well as academic partners including the National University of Singapore (NUS), Nanyang Technological University (NTU) and A\*STAR.

Singapore has instituted a robust, diversified and sustainable water supply known as the Four National Taps, comprising water from local catchments, imported water, desalinated water and NEWater. By taking

an integrative approach to maximize the efficiency of the Four National Taps, strategic initiatives and partnership projects are underway to harness Singapore's research strengths, elevating the city-state as a world leader in the application of recycled water and sustainable water management solutions. Since 2011, Singapore's water catchment area has increased from half to two-thirds of its land surface area through the completion



Singapore is a leader in water R&D and has developed NEWater, an ultra-clean, high-grade reclaimed water to help meet its needs.

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### Environment & Water Industry Programme Office

## Creating a global hydrohub for water solutions

Singapore has long been home to a thriving cluster of local environmental and water companies. Recognizing that local expertise and technology would be valuable to communities around the world in need of environmental and water management systems, the Singaporean government has incorporated the industry into its national growth plan. The Environment & Water Industry Programme Office (EWI) was thus established in 2006 to promote research and development in the field, grow the industry and position Singapore as a global R&D base for environment and water solutions.

Led by PUB, Singapore's national water agency, with funding of S\$470 million from the National Research Foundation (NRF), the EWI is well poised to meet its objectives: growing Singapore into a global hydrohub for leading-edge technologies and furthering Singapore's vibrant research community.

Over the years, Singapore has utilized innovative technologies and water management solutions to overcome its natural water resource challenges and develop a robust water supply for all of its consumption needs. As other countries around the world feel pressured to ensure sustainable freshwater supplies, they are

increasingly turning towards Singapore for expert guidance on this issue.

Today, companies base their operations in Singapore and collaborate with a community of over 100 companies and 25 research institutions within a vibrant water ecosystem. The EWI also accelerates the formation and growth of start-ups through financial incentives and mentoring. Funding opportunities for both basic and applied R&D projects are abundant, as are programmes for expediting commercialization of their results. In efforts to recruit young researchers, the EWI offers PhD scholarships for research on environmental and water technologies.

Test-bedding opportunities in PUB facilities, such water treatment plants, are a major drawcard for local and international companies looking to test new technologies under actual operating conditions, with over 100 new test-bedding projects seeded since 2007.

As the EWI's key initiative to showcase the capabilities of the Singapore water industry, Singapore International Water Week (SIWW) is a global platform that attracts the international water industry to share and co-create innovative water solutions. TechXchange, a key programme



The EWI is making water solutions possible.

of SIWW, brings together companies, angel investors, venture capitalists, start-ups and technology providers to discuss potential collaboration opportunities. More than 19,000 policymakers, corporate CEOs, water professionals and researchers from 104 countries and regions attended SIWW 2012. The next SIWW will be held in Singapore from 1-5 June 2014.

**Environment  
& Water Industry**  
Programme Office

[www.ewi.sg](http://www.ewi.sg)

of the Marina, Punggol and Serangoon reservoirs. With all major estuaries already dammed to create reservoirs, PUB aims to further harness water from the remaining streams and rivulets near the shoreline using technology that can treat water of varying salinity, which could boost Singapore's water catchment area to up to 90% of the land area in the long-term.

PUB is also deeply committed to research. One successful R&D

collaboration between PUB and Siemens has produced a demonstration desalination unit that is significantly more energy efficient compared to the best available technology. Instead of using reverse osmosis, which requires high-pressure pumps to force water through semi-permeable membranes, Siemens' engineers turned to electrochemical desalination — a process that combines electrodialysis and continuous electrodeionization

by applying an electric field to draw ions present in the sea water across ion exchange membranes and out of the water. As the demand for desalinated water will increase from the current 10% to up to 25% of Singapore's water demand by 2060, the total energy demand will increase by five times if Singapore continues to use reverse osmosis as a key desalination technology. Thus, the development of the new electrochemical desalination

technology will potentially save the country more than half of the total energy required by 2060. Besides the energy savings, other advantages of the new desalination system include low vibration and noise levels, improved safety and minimal pre- and post-treatment requirements.

Building on Singapore's strength as a global model for sustainable water management, the NTU launched the Nanyang Environment

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## National University of Singapore

# A leading research-intensive university in the heart of Asia

Consistently ranked as one of the top universities in Asia and the world, the National University of Singapore (NUS) is internationally respected for its high-quality research in science, technology and the humanities — and, increasingly, at the interfaces between these areas. Its 16 Schools and Faculties, as well as its 23 university-level research institutes and centres, focus on critical issues confronting Asia and the world. The university is also home to three of Singapore's five Research Centres of Excellence (RCEs) — specializing in quantum technologies, cancer and mechanobiology — and is a partner in a fourth RCE on environmental life sciences and engineering.

According to the *Nature Publishing Index 2012 Asia-Pacific*, the NUS is Singapore's leading research institution. It is ranked ninth in the Asia-Pacific region and is the first Singaporean institution to be in the Global Top 100. In the 2012 QS World Rankings, the NUS emerges at the top among Asian universities across all subject areas, and is also placed among the world's top 30 universities in 22 disciplines.

Much of the research at the NUS is integrated and multidisciplinary in nature, with particular emphasis on themes such

as: integrated sustainability solutions for energy, water and the environment; ageing populations; biomedical sciences and translational medicine; global-Asian studies; finance and risk management; and materials science.

In 2012, the NUS had more than 2,080 research-active faculty who produced over 8,800 publications and filed more than 360 patents and over 270 invention disclosures. Over 220 national and international research awards and prizes were given to NUS faculty. The overall level of primary research published by the NUS has led to its output being recognized by Thomson Reuters as being in the top 1% in 18 out of 22 categories surveyed. NUS faculty serve as consultants and advisors to more than 50 industry and government bodies. Several leading companies have also chosen to establish research labs and partnerships at the NUS, including Siemens, GE, Zeiss and Agilent.

The NUS Kent Ridge campus, which includes the National University Hospital, is located within Singapore's main research district. Its neighbours include the Campus for Research Excellence and Technological Enterprise (CREATE) at the NUS' University Town, which brings



The NUS campus is located in the centre of Singapore's dynamic research community.

together top researchers from around the world, A\*STAR, and a variety of public and private labs at the Science Parks. This proximity promotes collaboration and synergy between the NUS and the wider R&D community, and creates a fertile environment for education, innovation and enterprise.



[www.nus.edu.sg](http://www.nus.edu.sg)

and Water Research Institute (NEWRI) in 2008 and, in 2011 in partnership with the NUS, the Singapore Centre on Environmental Life Sciences Engineering — a leading research centre in microbial biofilms for water and environmental sustainability. Through transdisciplinary research on the environment and water, NEWRI develops innovative and practical solutions to environmental problems and

has brought water security to communities throughout Asia. At present, NEWRI comprises four Centres of Excellence — mathematical modelling and visualization, membranes, urban residues management and bioprocesses. The fifth centre, with a focus on environmental chemistry and materials, is currently in development. NEWRI also carries its own philanthropic arm that reaches out to various communities in

Asia to educate people and share knowledge on water resource conservation, pollution, mitigation and sustainable use.

### Fostering energy efficiency

The National Innovation Challenge (NIC) of Energy Resilience for Sustainable Growth (Energy NIC) was formulated as a whole-of-government effort to catalyse significant changes in Singapore's energy landscape.

The Energy NIC will develop cost-competitive energy solutions for deployment within 20 years to help Singapore improve energy efficiency, reduce carbon emissions and increase energy options. At the Energy Research Institute @ NTU (ERI@N), research is focussed on improving the efficiency of energy systems and maximizing the synergies of alternative energy sources through research on fuel cells, energy storage, sustainable

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## Nanyang Technological University

### A global leader in sustainability research

A research-intensive university in Singapore, the Nanyang Technological University (NTU) is the fastest-rising university in the world's top 50. In the QS Top 50 Under 50 — a ranking of universities that have been established in the last 50 years — the NTU is placed fourth globally.

The NTU, home to the world's largest engineering college, has grown in response to changing global dynamics from a purely engineering and technology university to one that also has strengths in business, science, humanities, arts, social sciences and recently medicine, with the establishment of the Lee Kong Chian School of Medicine set up jointly with Imperial College London.

A hub of innovation and technology, the NTU focusses its research in five interdisciplinary areas - sustainability, healthcare, new media, the best of East-West research, and innovation. The most significant thrust, and one that has clinched over US \$800 million in competitive research funding is sustainability.

Through two national research centres of excellence and several world-renowned institutes, the NTU takes an interdisciplinary approach to tackling environmental issues. The Energy Research Institute @

NTU focusses on clean and renewable energy; the Nanyang Environment and Water Research Institute leads the way in water treatment technologies; the Earth Observatory of Singapore studies tectonics, volcanology and climate change in Asia; and the Singapore Centre on Environmental Life Sciences Engineering applies its expertise in genomics to biofilms, biofouling and corrosion problems.

Complementing these advances on land, in air and in sea are the NTU's strides in space exploration. X-SAT, Singapore's first indigenous satellite, which is now orbiting in space, is helping scientists observe environmental changes. Also in the pipeline are three new satellite projects including Singapore's first tropical weather satellite that will conduct spaceborne monitoring of the world's tropical environment.

At the NTU, environmental stewardship and the culture of sustainability go beyond research in laboratories and in fact are the guiding principles of the campus and its development. New buildings and landscaping projects utilize, showcase and test-bed green technologies and enable ongoing research.

With more than two-thirds of the world's population projected to live in cities by



The school of Art, Design and Media at the NTU — winner of the BCA Green Mark Platinum Award for adopting best practices in environmental sustainability.

2050, there will be huge demands on future metropolises to provide housing, water and food, infrastructure and transportation and to ensure public health. By addressing these key global issues with an emphasis on sustainable metropolises, the NTU is taking the lead in many exciting research areas that will have the greatest impact on our planet.



[www.ntu.edu.sg](http://www.ntu.edu.sg)

building technologies, electromobility, solar energy and maritime energy, contributing to the goal of creating a greener and more sustainable future for Singapore's energy consumption.

ERI@N is mapping wind speeds, waves, currents and tides in the Southern Islands and coastal areas such as Tuas to test-bed wind and marine turbines. Recently, ERI@N has also engaged in a joint effort with Rolls Royce, Vestas, DNV, Keppel Offshore

& Marine, Lloyds Register and four other companies to research offshore renewables with emphasis on the southeast Asia region. To maximize sustainability on campus, the NTU is set to install a 5-megawatt solar photovoltaic system and cut energy intensity on campus by 50% by the year 2020.

Through a collaborative effort between the NUS and Singapore's Building and Construction Authority, a 'zero-energy building' (ZEB)

was made possible — the first of such buildings in southeast Asia. The project involved retrofitting an existing building to serve as the authority's academy, which houses offices, classrooms, a library and a visitor centre. The ZEB was designed to be fully powered by solar energy, drawing on the strength of Singapore's tropical climate where sunshine is in abundance. Currently, the ZEB is being tested as a model for

energy-efficient structures that could be applied throughout the country in order to help meet Singapore's mandate that at least 80% of its buildings become 'green certified' by 2030. In another effort, the NUS Department of Chemical and Biomolecular Engineering is exploring energy-efficient treatment of municipal solid waste to increase energy production and reduce the amount of waste disposed.

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## A\*STAR

## Where great minds meet and lead in advancing R&amp;D

Nestled in the twin R&D hubs of Biopolis and Fusionopolis is a thriving community of over 5,000 A\*STAR researchers and post docs from more than 60 countries. It is here at A\*STAR, the Agency for Science, Technology and Research, that the biomedical, physical sciences and engineering researchers mingle with one another as well as with other scientists from the corporate laboratories co-located within the hubs.

The proximity of the two hubs creates plenty of opportunities for the researchers to rub shoulders, pick each other's brains and benefit from the professional dialogue and the exchange of ideas.

A\*STAR attracts top-notch scientists, both local and international, who share the agency's vision of building a prosperous and vibrant Singapore through research



Biopolis has earned international reputé as major centre of biomedical research.

and development. They work alongside promising young scientists and contribute towards building a rich and diverse research landscape in Singapore.

It is at A\*STAR that world-renowned scientists such as Professor Sir David Lane, chief scientist of A\*STAR and the co-discoverer of the tumour-suppressor gene *p53*, and Dr Alex Matter, who discovered Glivec for the treatment of chronic myeloid leukemia, continue carrying out research that makes a difference. It is also at A\*STAR that promising scientists can focus on breakthrough research, such as Dr Joel Yang on his studies into the use of nano-printing methods to create colourful high-resolution images at 100,000 dots per inch and Dr Vrizlynn Thing on her innovative technologies for enterprise forensics investigative work.

A\*STAR's research institutes are also centres of choice for students and researchers beyond Asia who want to take part in undergraduate research attachments, or pursue their PhD studies and post doctoral stints. Over the past five years, more than 600 students and young researchers from more than 50 countries, including the United States, Brazil, the United Kingdom, Russia, Egypt, Sudan and Australia, have come to



Fusionopolis is Singapore's R&D hub for information, media and communication technology, physical sciences and engineering.

A\*STAR to experience working in a world-class research environment in Asia.

In a community as international and diverse as A\*STAR, researchers are constantly forging linkages with one another as well as with the scientific communities around the world. These connections go a long way in expanding Singapore's R&D landscape beyond its shores.



[www.a-star.edu.sg](http://www.a-star.edu.sg)

At the A\*STAR Institute of Bioengineering and Nanotechnology, there is a vision to develop alternative and renewable energy resources and technologies through the use of novel catalyst systems, which include the transformation of carbon dioxide into useful chemicals or fuels such as methanol. In November 2011, A\*STAR launched the Experimental Power Grid Centre, one of the largest experimental power grid facilities in the world. Built on Jurong Island, a man-made island off the southwestern coast of Singapore, the centre facilitates cutting-edge research and collaborations to develop future energy technologies in areas of electrical power networks, energy distribution and renewable energy resources.

### Instituting spaces with limited land

Creating new space cost-effectively and optimizing the use of space while maintaining liveability are the two thrusts of Singapore's second NIC. Led by the Ministry of National Development and the NRF, the Land and Liveability NIC will leverage R&D to provide sustained capacity and options for future generations. Initial funding is set at S\$135 million, and the Ministry of National Development launched a grant call in August 2012 to provide nearer-term seed funding for R&D to promote sustainable urban living and to kick-start research efforts in the areas of the Land and Liveability thrusts.

In line with the overall goal, A\*STAR's Science and Engineering Research

Council has created the Urban Systems Initiative to address the technological needs of the rapidly urbanizing world and to develop solutions for complex urban challenges through a data-centric approach. Through collaboration with local agencies such as the URA, the National Environment Authority and the Land Transport Authority, an integrated platform that gathers information through intelligent environmental sensing — to map traffic and noise in real time and optimize yield in urban vertical farming — could be established for use in holistic city planning.

The NUS is tackling the challenge of creating more useable space on a very small island. Its Department of Civil and Environmental Engineering

is developing technology that will enable developers to excavate underground tunnels of between 35–50 metres in diameter in soft soil conditions without risk of disruption to the ground surface above and its existing structures.

### Devising more efficient commuting solutions

Over the years, Singapore has built an extensive public transport system and implemented policies to discourage car usage due to the limited space available for roads. While travelling from place to place is relatively easy, roads already take up some 12% of the country's total land area. As Singapore continues to grow and travel demands increase, the ability to achieve more efficient commuting will require significant research into

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## Campus for Research Excellence and Technological Enterprise

### An international collaboratory

The Campus for Research Excellence and Technological Enterprise (CREATE) is an international research campus and innovation hub. Located in the tropical garden setting of the National University of Singapore's University Town (U-Town), CREATE will house about 1,200 researchers when it is fully occupied.



CREATE is a unique, international collaboratory in the heart of the National University of Singapore's University Town.

CREATE is an international collaboratory that brings together leading global research institutions with Singapore's institutions to do research in areas that are of interest and importance to Singapore and the region. Home to 15 interdisciplinary research centres from 10 renowned universities, CREATE encourages cross-fertilization of ideas through partnerships between researchers from diverse backgrounds and cultures. Research programmes are in the areas of Human Systems, Energy Systems, Environmental Systems, and Urban Systems.

The universities with research centres in CREATE are: Ben-Gurion University of the Negev; the University of Cambridge; the Hebrew University of Jerusalem; the Massachusetts Institute of Technology; Peking University; Shanghai Jiao Tong

University; the Swiss Federal Institute of Technology, Zurich; the Technical University of Munich; Technion — Israel Institute of Technology; and the University of California, Berkeley. CREATE also houses the SAP Singapore Research Centre and the National Research Foundation (NRF), Prime Minister's Office Singapore.

CREATE recently won R&D Magazine's 2013 Laboratory of the Year Award, for excellence in research laboratory design, planning and construction.

**CREATE**  
Campus for Research Excellence And Technological Enterprise

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new mobility options that are both efficient and acceptable to residents, as well as research to improve the planning, design and operation of public transport facilities. Even with an increased public transportation mode share, a large expansion of transport infrastructure and enhanced capabilities in managing increasingly complex transport infrastructure systems will be required.

Taking on the challenges ahead, the NTU and Germany's Technische Universität München (TUM) — two universities with globally acknowledged strengths in engineering — have come together with the NRF's Campus for Research Excellence And Technological Enterprise (CREATE) to embark on an ambitious electromobility research programme at a joint centre known as TUM CREATE. The taxi has been chosen as the platform on which to demonstrate the development of and innovations for the electric vehicle initiative.

The impact of taxis on urban cities is far greater than that of private passenger cars. Codenamed 'EVA', the electric-powered taxi created by TUM CREATE has been built specifically for tropical megacities, factoring in issues such as start-stop traffic conditions



TUM CREATE is developing innovative technologies, future transportation concepts and electric vehicles tailored to the unique needs of fast-growing tropical megacities.

and the need for powerful air conditioning. Funded by the NRF and wholly developed and produced in Singapore, EVA will be showcased at the Tokyo Motor Show in November 2013.

### Building a green urban city

Singapore has long been acclaimed as a garden city. Its rigorous environmental regulations and city planning guidelines manage pollution from industry and minimize its negative impact on the quality of life in Singapore. Today, close to half of the land area is covered by greenery, with thousands of species of flora and fauna thriving on the island. Continual R&D efforts are necessary to safeguard Singapore's greenery and biodiversity. Innovative new solutions such as sky-rise greenery, water-sensitive landscaping and ecological restorations will enable Singapore to continue to develop as a compact, liveable and resource-efficient city with rich biodiversity.

Beyond providing a sustainable supply of clean drinking water for a growing population, PUB is encouraging a bond to be formed between the Singaporean people and water by raising awareness of the scarcity and value of water in the city. Under the Active, Beautiful, Clean Waters Programme, PUB has transformed drains, canals and reservoirs into beautiful, clean streams, rivers and lakes that are integrated with the surrounding parks and green spaces. These bodies of water have the capacity to support water-based recreational activities such as kayaking, canoeing and sailing in addition to serving as community focal points for social events. The programme aims to bring people closer to Singapore's waterways and to inspire city dwellers to keep waterways clean and conserve

water. According to the Sustainable Singapore Blueprint 2030, Singapore's national framework for sustainable development, 900 hectares of reservoirs and 100 kilometres of waterways will be open for recreational activities by 2030, with at least 85% of the population residing within 400 metres of a park.

The development of Punggol Eco-Town in northeastern Singapore is an example of high-quality living integrated with water bodies through innovative planning, design and technology, and in partnership with the community. Dubbed the "Sustainable Waterfront Town in the Tropics", Punggol provides a wide range of quality housing and facilities and a well-integrated public transport network to serve the needs of its residents. A fully landscaped waterway of more than four kilometres was constructed to offer a unique "Green Living by the Waters" experience. At the same time, Treelodge@Punggol, the first ever eco-friendly precinct, was established setting a new benchmark for future public housing.

### Preserving a sense of belonging

Singapore is renowned for being one of the most harmonious and thriving multi-cultural cities in the world. To secure a future with social and cultural sustainability, the NUS, the URA and the Housing & Development Board are investigating how the design of housing estates and their surroundings could be modified to encourage community bonding and improve the liveability of existing and new towns. Among the group's aims is the creation of communal spaces that strike a chord with the different traditional and cultural habits of the core peoples that make up Singapore's

multicultural population — including coffee shops, wet markets, family-run businesses, communal event venues and playgrounds — while taking into consideration the evolving needs of Singapore's residents across all demographics.

Under the Ministry of National Development's Land Use Plan, one of the aims is for every resident to be no further than 10 minutes' walk from a station of the Mass Rapid Transit, Singapore's major metropolitan railway system. In addressing housing issues for the growing population, a supply of affordable homes will be ensured with all residents having easy access to a wide range of amenities such as schools, shops and healthcare as well as sports and recreational facilities.

### Improving daily life for everyone

Through the careful management of urban development needs and the use of innovative design, a good quality living environment can be created in a high-density setting. To optimize land use, it is necessary to develop new typologies, designs, technologies and other solutions to maintain good environmental quality and livability. Higher density neighbourhoods also create new opportunities to explore how information and communications technologies can improve quality of life by enhancing access to a wider range of urban services including retail, healthcare, social and community services. Virtual platforms with built-in analytics can provide realistic, simulated environments for cost-effective testing of integrated solutions, and for prediction and detection of emerging risks and systemic failures.

The Singapore Management University (SMU), a rapidly

expanding tertiary education institute situated in the heart of downtown Singapore, considers the entire island-state to be its laboratory for its study of analytics for the urban environment. Through its Living Analytics Research Centre (LARC), a joint research initiative between the SMU and Carnegie Mellon University in the United States, new techniques to acquire data on consumer and social behaviour

will be pioneered to develop applications and methods of direct benefit to consumers, businesses and society.

Running in parallel to LARC, the SMU's LiveLabs initiative conducts large-scale trials and experiments in real time that incorporate novel mobile services and investigate the changing values and attitudes of Asian consumers in actual environments. Singapore is an ideal test bed for such studies due to

its position as a multicultural urban centre with a high-quality infrastructure. The SMU's School of Information Systems has become a leading centre for research and education in intelligent systems and decision analytic applications for supply chain sustainability.

The university has also been careful to not neglect the needs of ageing residents in Singapore. Teaming up with Tata Consultancy Services

(TCS), the SMU-TCS Intelligent City Laboratory was launched to assist cities in their quest to become more effective and efficient in addressing and serving the demands of their populations. One of the core projects undertaken by the laboratory is the design of a centralized platform for healthcare professionals and aged patients that facilitates self-assessment, appointment booking and

## PROFILE

## Singapore Management University

### Computational social science in the heart of the city

Situated in the heart of Singapore's arts and cultural district, the Singapore Management University (SMU) is focussed on social and behavioural science, management and information technology.

The SMU's tagline is "The University for the World of Business and Management", and an important part of its strategy is in the emerging area of computational social science and analytics. Examples of the SMU's work include the following projects.

The Living Analytics Research Centre (LARC) is a five-year partnership between the SMU and Carnegie Mellon University, concentrating on obtaining and analyzing 'digital traces' of consumer and social behaviour from private sector, social media and public sector data sources. The centre's distinctive approach to combining analytics with systematic and iterative field experiments has caught the attention of companies such as Citibank Singapore, Starhub, Buzzcity, Sentosa Development Corporation and Resorts World Sentosa who are working as collaborators with the centre.

The LiveLabs Urban Lifestyle Innovation Platform is a city-scale research test bed for companies to run large-scale consumer behaviour and social interaction trials. Key

test-bed sites in Singapore include Changi Airport, Sentosa, the SMU downtown campus and shopping malls operated by CapitaMalls Asia. LiveLabs technologies make it possible to move beyond geo-spatial information collection to context awareness as a basis for real-time consumer and social interaction. LiveLabs also provides LARC researchers with a unique platform for performing large-scale, controlled field experiments.

The university is increasingly applying its capabilities in social science, business and computation to the area of urban management. It is working with partners such as Tata Consultancy Services through the SMU-TCS iCity Lab, DHL Supply Chain and parts of the Singaporean government on research that includes multi-party coordination of city logistics, data analytics and optimization for urban infrastructure security, sustainable supply chains, and city process management for improving service delivery to cater to the special needs of the population.

Since its founding in 2000, SMU's extensive collaborations with private and public sector organizations, its strengths in computational social science and analytics, and highly accomplished



The SMU is set to lead in the emerging field of computational social science.

faculty have enabled it to build an international reputation in research, education and practice.

SMU is a vibrant player in Singapore's research and development landscape focussed on social and behavioural science, management, and information technology, and is well positioned to lead in the twenty-first century.



[www.smu.edu.sg](http://www.smu.edu.sg)

the maintenance of social connections while at the same time utilizes users' data for improved policy making.

### Facilitating the rapid detection of infections

Growth of Singapore's population may be accompanied by an increased likelihood of the transmission of infections, with rising migration and tourist numbers also intensifying the nation's vulnerability to disease

transmission. In 2012, more than 51 million passengers passed through Singapore Changi Airport; a huge volume of people that emphasizes the utmost importance of infectious disease monitoring and control. Drawing on experiences from the severe acute respiratory syndrome (SARS) outbreak in 2003, many current research efforts are set on understanding influenza viruses as well as developing rapid diagnostic kits.

In collaboration with the National Public Health Laboratory of Singapore, the World Health Organization (WHO) collaborating centres in Australia and the A\*STAR Genome Institute of Singapore, the A\*STAR Bioinformatics Institute has created an online tool called FluServer that allows quick and efficient analysis of influenza genomic sequences and interpretation of mutations. Recently, the A\*STAR

Experimental Therapeutics Centre signed a licencing agreement with the Tan Tock Seng Hospital and local biotechnology company AITbiotech to market a made-in-Singapore H5N1 bird flu diagnostic kit that allows the detection of all existing strains with almost 100% accuracy and in just a few hours from a single test.

Singapore is a prominent global health and biomedical research hub set in a tropical

## PROFILE

### Singapore University of Technology and Design

## A better world by design

The Singapore University of Technology and Design (SUTD) is Singapore's fourth publicly funded university and one of the first universities in the world to incorporate the art and science of design and technology into a multi-disciplinary curriculum. Established in collaboration with the Massachusetts Institute of Technology (MIT), in the US, the SUTD seeks to nurture technically grounded leaders and innovators to serve societal needs.

The SUTD, also in collaboration with Zhejiang University, China, and the Singapore Management University, is distinguished by its unique Eastern and Western academic programmes that incorporate elements of technology, entrepreneurship, management and design thinking.

The university offers a common curriculum for the first three terms of undergraduate



The SUTD's permanent campus at Singapore's East Coast.

study, called 'Freshmore', to provide strong technical grounding before students select one of the four majors known as 'pillars': Architecture and Sustainable Design; Engineering Product Development; Engineering Systems and Design; and Information Systems Technology and Design – leading to the corresponding degrees.

At the SUTD, design as a discipline cuts across the curriculum and provides a novel framework for the research and educational programmes. Termed 'Big-D', the curriculum will encompass every technology design imaginable – from process design to architectural design, product design, software design and systems design. Students will also learn to define problems holistically and develop creative solutions from a total-design perspective. They will experience the full value chain from conception through development, prototyping, manufacturing, operations and maintenance.

The SUTD also offers graduate programmes. In the two-year full-time MIT-SUTD Dual Masters' Degree Programme, one year is spent at MIT on coursework and the other at the SUTD in research, leading to two master's degrees – one from MIT and another from the SUTD. Graduate opportunities also include the SUTD PhD Programme, a three-



The SUTD campus fosters collaboration, invention and creativity.

to five-year residency comprising research, course work, potential industry internships and overseas research exchanges.

The world is in need of technically grounded leaders to address pressing issues concerning sustainable energy, growing and ageing populations, urbanization and scarce resources – making innovation and technical leadership national priorities. Graduates of the SUTD will be prepared to contribute to such areas, which are critical to the world's social and economic development.



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climate; as such, its researchers are well placed to study and devise treatments for infectious diseases such as dengue fever that are endemic to the region. Although there are a number of dengue vaccine platforms in clinical trials, the data has so far proven disappointing, prompting an urgent need for new therapies. In collaboration with local scientists and clinicians from the NUS, the DSO National Laboratories, the National University of Health Sciences and Israel's Hebrew University of Jerusalem, a human antibody from a recovered dengue patient was successfully isolated and cloned. The antibody exhibits remarkable efficacy in protecting against dengue infection and will be taken into vaccine clinical trials in Singapore in 2013.

### Designing a better future

Singapore's newest university, the Singapore University of Technology and Design (SUTD), aims to achieve a better world through innovative design. Teaming up with the Massachusetts Institute of Technology (MIT) in the United States, the SUTD-MIT International Design Centre was inaugurated in 2012. The centre is envisioned as a global hub for technologically intensive design that creates solutions to the current and potential problems that global societies face. It has identified three Design Grand Challenges: Sustainable Built Environment, Design with the Developing World, and Information and Communications Technologies-enabled Devices for Better Living. A prime example for the Design with the Developing World Challenge is OttoClave, an affordable autoclave made from a household pressure cooker that can bring medical

instrument sterilization to remote health posts in the developing world.

In line with Singapore's mission to lead as a world-class city boasting a high quality of life and urban solutions, the SUTD also established the Lee Kuan Yew Centre for Innovative Cities to educate leaders and develop products, services and systems for improving the lives of city dwellers. The new institute is named after Singapore's founding father and former Prime Minister Lee Kuan Yew, honouring his vision of building Singapore into a prosperous global city.

### Looking ahead with optimism

Singapore today, with its gleaming skyscrapers and cosmopolitan people, may seem a world apart from its humble origins. The city-state has replaced the early squatter colonies and slums with modern housing and an enviable standard of living. With an eye to the future, the country must enable current generations of Singaporeans to find creative ways to keep the economy growing and thriving while acting as stewards of the environment. Furthermore, Singapore must remain the country of choice for its people to build their families and careers in.

To this end, science and technology can catalyse the development of innovative and comprehensive urban solutions to sustain Singapore's growth and resilience, as well as build talent and manpower capability that can be deployed to derive practical benefits for Singapore and other cities facing similar urban challenges. The NRF, together with the entities highlighted in this feature, is committed to continuing the mission of Singapore by integrating research



The NRF supports promising Singapore-based research by up-and-coming scientists at the Global Young Scientists Summit.

activities across all disciplines into the larger R&D ecosystem to support scientific advancement in world-class education, optimal healthcare, sustainable resources and creation of pleasant living environments for the nation's residents.

As part of efforts to support new ideas and stimulate the local R&D landscape, a record number of NRF Fellowships were awarded in January 2013 to fund research undertaken by promising young scientists. The awards provide each winner, whose research interests range from cancer to earthquake faults in southeast Asia, with up to S\$3 million over 5 years to perform research based in Singapore. Complementing the NRF's efforts, A\*STAR offers a range of scholarships to both local and international students to pursue a career in science and technology.

In 2013, the NRF organized the inaugural Global Young Scientists Summit, an international gathering in Singapore for bright young researchers from all over the world to be inspired by internationally eminent science and technology leaders. An integral part of the summit was the Singapore Challenge, a competition

which centred on the theme 'Innovations for Future Cities'. The top award was presented to A\*STAR research scientist Lynette Cheah for her proposal to build a transport network that provides real-time feedback so commuters can change their plans accordingly. To encourage new ideas for urban solutions, Singapore is also host to the Lee Kuan Yew World City Prize, a biennial international award that honours outstanding achievements and contributions to the creation of liveable, vibrant and sustainable urban communities around the world.

Singapore is poised to become one of the top cities in Asia in terms of environmental quality, economic opportunity, social attainment and connectedness to global flows. While carving out an even stronger international profile by forming a greater number of R&D collaborations worldwide, the nation has pledged not to lose sight of the needs of its citizens. Singapore's appreciation of the evolving needs of its people and their surroundings will attune it to adopting a sensitive and flexible stance, as it always has, in embracing innovations to sustain growth and liveability. ■