ONE-NORTH: FOSTERING RESEARCH, INNOVATION AND ENTREPRENEURSHIP

one-north: Fostering Research, Innovation and Entrepreneurship chronicles the genesis, planning and development of one-north. A key element of Singapore's Technopreneurship 21 initiative, one-north provides an intellectually stimulating and creative environment to attract world-class research talent and investments to drive the next phase of the country's development. Planned as a work, live, play and learn environment, the innovation district symbolises Singapore's response to changing economic circumstances and its transformation into a knowledge economy. This study examines the development of Biopolis, Fusionopolis and Mediapolis as clusters for industries in biomedical sciences, info-communications technology and media, supported by capabilities in science and engineering.

"Singapore understands she can never replicate the expansive land of Silicon Valley and [its] enormous amount of continuous investments. She needed strategies that would turn disadvantages of limited land into strength...in response, one-north broke away from the preceding lower density mono-work-zoned technology parks to harness the energy of innovation from high-density urban life...one-north represents Singapore's determination to become the Silicon Valley of Southeast Asia, and to solidify its key role in growing the region's innovation economies. Today, more than 15 years since its inception, one-north remains a visionary project to watch, to share in the joys of its success, and perhaps to learn from its mistakes".

Dr Arthur Aw, former Director of Land Planning, JTC Corporation

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ONE-NORTH: FOSTERING RESEARCH, INNOVATION AND ENTREPRENEURSHIP

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Set up in 2008 by the Ministry of National Development and the Ministry of the Environment and Water Resources, the Centre for Liveable Cities (CLC) has as its mission "to distil, create and share knowledge on liveable and sustainable cities". The CLC's work spans four main areas—Research, Capability Development, Knowledge Platforms, and Advisory. Through these activities, the CLC hopes to provide urban leaders and practitioners with the knowledge and support needed to make our cities better. For more information, please visit www.clc.gov.sg.

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FOREWORD

By the 1990s, as other countries in our region were fast catching up, Singapore had to move up the value chain and create a knowledge-intensive economy. To stay competitive, Singapore had to upgrade its industries through value-added research and development (R&D), and innovations in the chemicals, electronics and engineering sectors. In February 2001, I took on the appointment of chairman of the National Science and Technology Board (NSTB). I took a pro-active approach to nurturing Singapore's scientific human capital and investing in R&D capabilities and capacities in two key clusters: biomedical sciences, and physical sciences and engineering. We renamed the NSTB as the Agency for Science, Technology and Research (A*STAR) to attract and capture local and international scientific talent.

We needed to quickly build next-generation physical infrastructure to attract the right type of knowledge-intensive activities and human capital. This became one-north. It was designed to house knowledge and innovation-based industries such as biomedical sciences, info-communications technology and media, supported by capabilities in science and engineering. Biopolis, the first cluster to be developed in one-north, was special. Biopolis was Singapore's first hub for R&D in biomedical sciences. Until then, we had industrial and business parks clustered by sectors or functions that essentially revolved around manufacturing. one-north supports a dynamic ecosystem to translate research and knowledge into something of practical and commercial value.

Much planning and design went into creating a 'work-live-play-learn' environment in one-north. It would be a sustainable ecosystem of players—from world-class research institutes to high-tech companies, universities, creative start-ups and supporting services. The idea was to bring together a vibrant community that would spark new ideas. Even the name Biopolis reflected this concept, wherein 'bio' referred to biomedical sciences, and 'polis' was the ancient Greek word for city. JTC Corporation, A*STAR and the Economic Development Board, as a team, moved quickly, and Biopolis Phase One opened for business on 29 October 2003.

Biopolis has been instrumental in bringing together researchers from public and private organisations to form close collaborations. Its significant breakthroughs include the severe acute respiratory syndrome (SARS) detection kit co-developed by A*STAR's Genome Institute of Singapore (GIS) and Roche Diagnostic, and the macromolecule, which prevents deadly virus infections, identified jointly by IBM Research and Singapore's Institute of Bioengineering and Nanotechnology (IBN). They placed Singapore on the global map for biomedical research.

Since then, one-north has spawned other mini-cities—Fusionopolis, Mediapolis and even a start-up cluster, LaunchPad @ one-north. Far from simply a science or business park, one-north is home to a growing community of knowledge and research-intensive enterprises and talents. Its conducive environment is equipped with residential, social and recreational amenities. From its beginnings in Biopolis, the one-north community is blossoming slowly, but surely.

one-north: Fostering Research, Innovation and Entrepreneurship details the genesis, planning, and development of this unique hub. It highlights how a pioneering project, envisioned as a trailblazing next-generation science park, capitalised on emerging developments in science and technology to set the stage for Singapore's transformation to a knowledge-intensive economy.

Philip Yeo
Chairman
Economic Development Innovations
Singapore (EDIS) Pte Ltd

PREFACE

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

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

The CLC would like to thank the JTC Corporation and all those who have contributed their knowledge, expertise and time to make this publication possible. I wish you an enjoyable read.

Khoo Teng Chye
Executive Director
Centre for Liveable Cities

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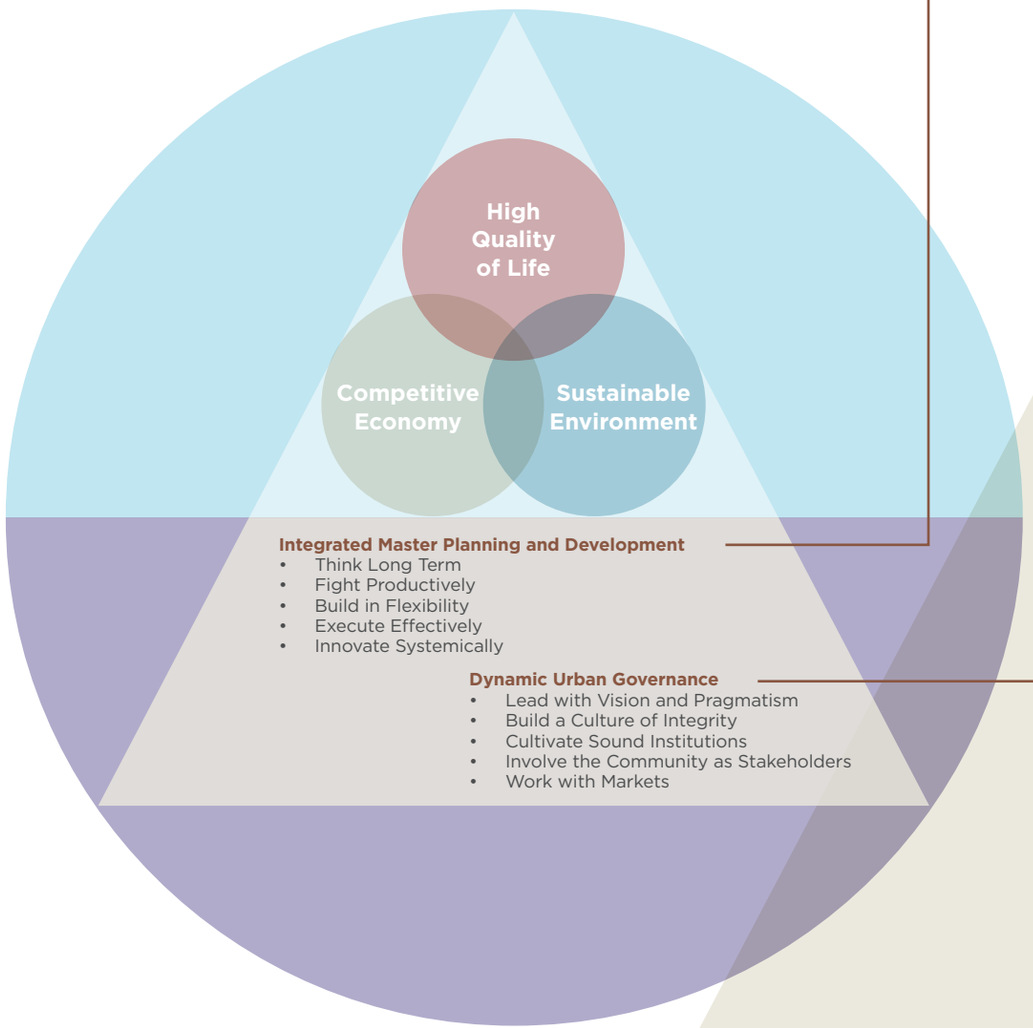
The writer, Phua Shi Hui, wishes to express thanks to Michael Koh and Hee Limin for their guidance. She would also like to extend her gratitude to CLC colleagues—Amit Prakash, Cherub Ho, Erin Tan, Jason Boh, Luther Seet, Katyana Melic, Remy Guo and Chng Ming Han, as well as JTC colleagues—Sandy Loo, Cindy Chou, Lai Quan Hui and Jin Hao. Lastly, she would like to thank Eric Tan for his constant support.

THE SINGAPORE LIVEABILITY FRAMEWORK

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

The general principles under **Integrated Master Planning and Development** and **Dynamic Urban Governance** are reflected in the themes found in *one-north: Fostering Research, Innovation and Entrepreneurship.*



Integrated Master Planning and Development

Think Long Term

The 1991 Concept Plan safeguarded the current site in Buona Vista for the development of a Science Hub, which was subsequently named one-north. In keeping with the overarching objective of facilitating growth of high-technology industries, the Concept Plan proposed taking advantage of the existing Science Park I and II, the National University of Singapore and the Nanyang Technological University to form a continuous belt along Singapore's southwest coast. The long-term development strategies underpinning the Concept Plan set the ground for the creation of a technological corridor, providing researchers at one-north with an integrated working, living and leisure environment.

(see "Greater one-north Area", p. 18)

Fight Productively

As one-north was conceptualised as a sandbox for technological and regulatory innovations, a group set up within the JTC to spearhead its development understood that boundaries needed to be pushed in order to create an ecosystem for technopreneurship. Hence, in developing one-north, conventional planning norms were challenged in terms of building setbacks, road sections and land-use zoning. The one-north Steering Committee was formed to address and resolve inter-agency conflicts.

(see "Challenging Planning Guideline Norms", p. 26)

Build in Flexibility

A degree of flexibility is essential for one-north's success. One of the significant breakthroughs in one-north has been the application of 'white use'. Allowing flexibility in land use allocation at the broader district level, rather than at the plot level, enables developers to adjust the different land use types within each development. The ability to change the mix and proportion of the 'work' and 'live' components equips them to better respond to changing market conditions, thereby improving the probability of success.

(see "Challenging Planning Guideline Norms", p. 26)

Dynamic Urban Governance

Lead with Vision and Pragmatism

The 1991 Concept Plan recommendation to develop a Science Hub fitted well with government proposals for the development of science and technology to enable Singapore's economy to move up the value chain. When Teo Ming Kian was appointed Chairman of the National Science and Technology Board in 1993, he saw the need for Singapore to shift to

a more technology-intensive phase of economic development, and from there to a knowledge and innovation-driven economy. This required the development of science and technology to be intensified, and for research to be nurtured and commercialised for economic impact. A physical focal location to signify the intersections of science and technology with businesses, especially technopreneurial endeavours, would help bring about this strategic shift. This took time and perseverance. The development of one-north finally started in 1998 with a Development Committee to champion and provide the detailed concept for implementation. one-north became a key element of the government's Technopreneurship 21 initiative to transform Singapore into a knowledge-intensive economy.

(see "Developing a Technopreneurial Economy", p. 1)

CHAPTER 1

DEVELOPING A TECHNOPRENEURIAL ECONOMY

> I thought that [the Buona Vista Science Hub] being considered was going to be just another science park, where we already had two [Science Park I and II]. So, we began to think, really what is it that we should try to evolve [that] will make a real difference? Not just physically, but really providing [an] environment conducive for that sort of technopreneurial economy to evolve.[1]

Teo Ming Kian

Singapore's first Prime Minister, Lee Kuan Yew, famously remarked in 1957 that the idea of an independent Singapore was a "political, economic, and geographical absurdity".[2] He was alluding to Singapore's position as a young nation that, save for its favourable geographic location, had few natural resources. However, since gaining independence in 1965, Singapore has continued to transform its economy to meet evolving challenges and attain intensified levels of development in its 53-year history.

The development of one-north as the epicentre of Singapore's knowledge and innovation-driven industries symbolises the city-state's evolution in response to changing economic circumstances and industrial trends.

Since the 1960s, Singapore's economy has undergone a gradual, but deliberate shift. Its industrialisation began with the establishment of the Jurong Industrial Estate, which focused on attracting labour-intensive industries. By the 1970s, Singapore embraced skill-intensive industries, bringing vocational institutes such as the Japan-Singapore Institute and the German-Singapore Institute to provide manpower suited to the newly established industries that were reliant on automation and required a skilled workforce. The 1980s witnessed a more capital-intensive phase of development, with industries such as chemicals, petrochemicals and wafer fabrication being wooed to Singapore's shores.[3]

The overarching challenge for Singapore's economy in the 1990s was shifting the nation's growth engine from industries reliant on an abundance of low-skilled labour, to those requiring skilled workers for high-technology industries.[4] The grain of economic and industrial activities was starting to change. No longer focused solely on manufacturing, Singapore's economy was turning towards design as well as research and development (R&D).[5]

A fundamental review of Singapore's economy following its first post-independence recession in 1985 recognised the importance of undertaking structural reforms to promote innovation, enterprise and entrepreneurship.[6] Upgrading economic activities would allow Singapore to continue on its growth path, and transition from a developing nation to a developed one. Diversification was also an area of primary focus in order to help reduce the country's susceptibility to economic shocks, while creating new growth engines. Then Deputy Prime Minister Tony Tan wanted to promote technopreneurship and innovation to catalyse the change.[7] Technopreneurship, as distinct from entrepreneurship, focuses on enterprises that rely heavily on technology. These enterprises require a talent base capable of creating and commercialising new intellectual property into businesses. They also need financial support from channels such as venture capitalists that can take on greater risks than traditional funding sources such as commercial banks.[8]

Teo Ming Kian, former Executive Chairman of the then National Science and Technology Board (NSTB)—which was renamed Agency for Science, Technology and Research (A*STAR) in 2001—felt that investment in research would provide the foundation for the country to enter the next phase of development, one marked by the intensive use of technology.[9] This would enable Singapore to move from the manufacturing of products to the creation of knowledge and innovation, where the economic rewards were greater. Focusing on research would also create space for setting up of research labs by multi-national corporations (MNCs) and home-grown companies.[10] However, in order to create new technologies, the first step that needed to be taken was the laying of a basic R&D infrastructure that could be built upon.

TECHNOPRENEURSHIP 21: A NATIONAL INITIATIVE TO DRIVE INNOVATION

> *one-north [was] actually conceived during [an] economic climate where it [was] important for [Singapore] to move from our previous phases of development to a new phase, which is more knowledge-intensive.*[11]
>
> Tan Chin Nam

As Singapore's economy entered a knowledge-intensive phase, R&D was thought to provide the next avenue of pursuit in its quest for a better quality of life for its citizens. With this in mind, the Technopreneurship 21 (T21) programme was launched in 1999.[12] Initiated as a whole-of-government effort headed by the NSTB, in collaboration with the relevant government agencies and private organisations,[13] the aim of the T21 programme was to foster innovation-driven enterprises with global ambitions.[14] With a two-pronged blueprint to promote technopreneurship, Singapore would build a climate conducive for investments in science and technology, while concurrently nurturing a generation of people equipped with the expertise, innovativeness and grit to bring new discoveries to market.[15] The T21 blueprint was a major initiative to put in place a technopreneurship ecosystem, but it faced overwhelming challenges of funding, as well as those arising from the existing education system and policy structures.[16]

Concrete steps taken to achieve objectives of the T21 programme included the Ministry of Education's "Thinking Schools, Learning Nation" initiative to develop creativity and critical thinking skills, as well as programmes such as BizWorld to introduce the fundamentals of business and entrepreneurship to schoolchildren aged 10 to 14 years.[17] With the creation of a US$1 billion Technopreneurship Investment Fund, venture capitalists were invited to set up base in Singapore to help fund start-ups.[18] Attracting international talent that could help jumpstart Singapore's budding technology scene was aided by the relaxation of immigration rules through the introduction of the Technopreneur Pass scheme and modification of Long-Term Visit Pass visas.[19]

However, generating vital support for the idea that Singaporeans could be creative and entrepreneurial was challenging. With the technopreneurship and R&D movements still nascent, there was need for a core project to focus capital and efforts on. A physical hub was necessary to show Singaporeans that a career in research was feasible, and not solely tied to academia.[20] Under the T21 programme, the development of a Science Hub to provide an intellectually stimulating and creative environment for talent to congregate, and for a community of technopreneurs to interact, was identified as a key element.[21]

At the same time, external pressures were surfacing. There was news from Malaysia of plans for a high-technology business district, which later came to be known as the Multimedia Super Corridor (MSC). The MSC, conceptualised in 1996, was envisioned to be a hub for innovative producers and users of multimedia technology, with the town of Cyberjaya planned as an intelligent district with information and communications technology (ICT), multimedia industries, R&D centres and operational headquarters for MNCs.[22] The MSC was part of Malaysia's plan to propel its economy to the next stage of development by nurturing local enterprises and attracting foreign ICT-related businesses.

Singapore came to realise that there would be a first-mover advantage in setting up the initial innovation hub in Southeast Asia. At the time, while the NSTB was investing in research locally with marginal results, former Executive Chairman Teo thought more could be done to support the initiative. He saw the potential to energise local players and extract additional value from available resources in Singapore.[23] By inviting global industry leaders to create local research powerhouses, the city-state could regain its economic lead in the region.

These internal and external pressures eventually cumulated in the announcement of a proposed Science Hub by then Deputy Prime Minister Tony Tan at TechVenture 98, a conference for technology start-ups, on 15 September 1998. The Science Hub would achieve three benefits: positioning Singapore for high-tech industrial activities, creating a focal point for R&D and high-tech activities, and developing an innovation milieu in the country.[24]

PROPOSED SCIENCE HUB IN BUONA VISTA

In an effort to understand what kind of a Science Hub was needed, a multi-agency team was sent on study trips to research parks across the globe with the key objective of learning about the building blocks necessary for a successful research cluster. A key insight gleaned from such visits was the close relationship between academia and research. The Research Triangle Park at Chapel Hill, North Carolina, in the US stood out, among others. The three universities in its vicinity—Duke University, NC State University and the University of North Carolina at Chapel Hill—had close

ties to the research park, creating synergies through the mingling of academia and private institutions. Another example was Kendall Square, which had an emerging biotechnology cluster, located just outside Boston in proximity of the Massachusetts Institute of Technology (MIT). The study trips convinced the multi-agency team of the importance of locating the upcoming science hub next to a university.[25] Another observation was that most science parks lacked vibrancy, with employees coming to the park to work during the day and leaving it deserted and dead at night.

In line with overarching efforts to facilitate the growth of high-technology industries, Singapore's 1991 Concept Plan suggested taking advantage of the presence of the existing Science Park I and II, the National University of Singapore (NUS) and the Nanyang Technological University (NTU), which collectively formed a belt along Singapore's southwestern coast. This set the ground for a potential technological corridor that would provide researchers an integrated working, living and leisure environment.[26]

A site of approximately 200 hectares (2 km^2) at Buona Vista, located off Commonwealth Avenue, was earmarked as the new Science Hub.[27] The site had unique features that could not be replicated elsewhere in Singapore. It comprised of army camps, Urban Development and Management Company (UDMC) bungalows, the Ayer Rajah Industrial Estate and vacant state land.[28] Close to the NUS, Singapore Polytechnic, National University Hospital and Singapore Science Park, the plot was surrounded by land uses and functions that were complementary to a research hub. There were also established housing estates in Dover and Commonwealth equipped with reputable private and public schools. In addition, transport infrastructure in the area was well developed, with the Buona Vista Mass Rapid Transit (MRT) station at a stone's throw, and the central business district a 10-minute drive away. Its locational properties had to be maximised, not by constructing another office park, but by tapping on the NUS' value as a hotbed of innovation, and by building strong linkages between the proposed Buona Vista Science Hub (BVSH) and these educational institutions to aid the cross-fertilisation of ideas, and facilitate partnerships between industry and research.[29] Most importantly, the state-owned land was available for development as the army camps were being phased out.

With the technological corridor in mind, the BVSH was to be the core of this intensified research thrust. While the Science Hub might be physically confined by the hard infrastructure, its ideas and developments would spread beyond its physical boundaries and intermingle with the science parks and academic institutions stretching along the southwestern coast.

BUONA VISTA SCIENCE HUB: NEXUS FOR RESEARCH AND ENTREPRENEURSHIP

Buona Vista Science Hub (later renamed one-north) was envisioned as a nexus for research and entrepreneurship.
Photo courtesy of JTC Corporation.

By the late 1990s, Singapore had successfully constructed a plethora of business and science parks to meet the needs of different industries.[30] These included the initial Singapore Science Park developed in the 1980s along the Ayer Rajah Expressway, adjacent to the NUS. Businesses including MNCs were attracted to these parks due to their cheaper rents and large floorplates. However, there was little to encourage interaction between businesses, which were housed in buildings ringfenced by carparks that separated the buildings. While the established MNCs had contributed significantly to Singapore's economic growth, there was little to keep these companies in Singapore if other cities offered more favourable conditions.[31] This standard business park typology created silos, which was thought to run counter to the BVSH's primary goal of being a research hub. A new typology would have to be created to differentiate Singapore and encourage the setting up of R&D capabilities among local enterprises.

> *NSTB wanted to have an environment that supported technopreneurship and felt that Science Park I and II...were not conducive for the kind of people they wanted to attract, which are [of an] entrepreneurial and technopreneurial-type of mindset.*[32]
>
> Chong Lit Cheong

Unlike the existing business and science parks, the BVSH was envisioned to be a well-mixed ecosystem of multidisciplinary researchers, technopreneurs, scientists and venture capitalists in a conducive environment that fostered creativity and risk-taking. The idea of fusion was a central tenet of the BVSH. The district could be viewed as a prototype development, representing an evolution from the standard science and business parks.[33] The importance of interaction came about during a study trip to South of Market (SoMa) in San Francisco. In the 1990s, SoMa housed a healthy cluster of technology companies, with 'live-work' buildings in the area attracting a vibrant mix of people. The area's vibrancy attracted not only people working within SoMa, but also urbanites looking for an energetic environment to hang out.[34] This greatly increased the chances for serendipitous meetings, a factor thought to encourage innovation.

It was also observed in technology parks located in Irvine, California, and Alexandria Technology Square in Greater Boston, that workers in the technology sector gravitated towards an urban rather than suburban environment. Similarly, the younger generation of workers observed in Silicon Valley and Boston areas also preferred an urban environment where they could enjoy being able to walk from their workplace to have a cup of coffee with others. Most eschewed commuting long distances to work, preferring to live close to their place of employment.[35] By seeking to create such an environment in BVSH, the idea was that the best and the brightest from around the world would be attracted to live and work in Singapore.

This led to the recognition among Singapore's agencies that business parks should not be designed only for certain types of workers. Instead, there was a need to make the BVSH attractive to different segments by including more recreational as well as food and beverage (F&B) options.[36] The BVSH thus represented a paradigm shift for industrial land use in Singapore, from performing the sole function of manufacturing and production, to becoming a place where people could now work, live, play and learn. In the process, the land at the BVSH would experience an intensification of use, which suited land-scarce Singapore.

By applying a mixed-use approach to the BVSH, an even spread of people could be maintained throughout the day, generating a sense of energy at all times. The creation of nodes to facilitate informal interaction would act as a bridge for people to 'collide', creating a spirit of community and exchange.[37] Furthermore, by separating the clusters, the intention was for the clusters to grow organically and mix, potentially resulting in new industries being born along the points where they meet.[38] A people mover system linking up the compound was also mooted at conception. Housing, leisure and green spaces were also to be developed, a key differentiator from previous science parks.[39]

Hence, the BVSH had to be developed differently from a typical science park. Rather than being used purely as office and research space, the site would include a variety of uses including residential and entertainment amenities. The BVSH was envisioned as a self-contained precinct, comprising a community of schools, businesses and research centres, with everything that researchers would need to work, live, play and learn. It would be home to a community bonded through physical proximity and a wide range of activities organised throughout the year. It was hoped that the co-mingling of different organisations and companies, within a carefully designed physical space aimed at fostering interactions and cross-fertilisation of ideas, would spur innovation and new ideas. Some of these ideas could lead to inventions that could be commercialised and monetised within the ecosystem of technopreneurs, who would invest in developing products and services. The BVSH was not simply a physical space, but one which the NSTB could also support in terms of policy and grants.[40]

The steering agency for the T21 programme was transferred from the NSTB to the Economic Development Board (EDB) in January 2001. This was done because the EDB had traditionally been the statutory board tasked with the development of future industries in Singapore.[41] With the EDB advocating the development of business and science parks, the BVSH would serve as a flagbearer of the knowledge economy that Singapore had envisioned.[42] By then, the vision for the BVSH included the creation of a new biomedical sciences research cluster that would generate value-add projected to be $1.5 million per worker each year, and create ancillary jobs, such as nursing, data analysis and a downstream flow of employment.[43] Additionally, bringing in companies with a global presence and technical expertise would create a conducive environment for nurturing start-ups.

CO-LOCATION OF BIOMEDICAL SCIENCES, INFO-COMMUNICATIONS AND MEDIA, FINANCIAL AND BUSINESS SERVICES

> *If we are able to create an environment where small and big, foreign and local enterprises can interact...we will create an environment...a competitiveness that very few people will be able to match. That, in a way, [is] a much larger idea than just physical and clustering or zoning.*[44]
>
> Teo Ming Kian

The choice of clusters to be located within the BVSH was not predetermined at the outset.[45] This retained developmental flexibility, allowing these clusters to evolve, and new ones to emerge, as the knowledge economy developed. Within the BVSH, respective industry players were clustered in nodes to foster collaboration among like-minded companies and individuals.[46] Each cluster embedded in the BVSH was conceptualised to chart a path to the future. It was only after much deliberation that the key industrial clusters of biomedical sciences, info-communications and media, financial and business services were identified, with space set aside for development of future clusters.[47]

The clustering of industries was not in itself a ground-breaking idea at the time. Precedents included wafer fabrication plants in Woodlands and petrochemicals plants on Jurong Island.[48] However, the BVSH was different in that its focus was on intangible 'research'. The clustering of these R&D organisations and facilities not only provided the usual benefits of sharing common infrastructure, such as precision equipment, it also allowed the exchange and growth of ideas that are essential for R&D.

The creation of a community of public and private research institutes, along with educational institutes creates a community that breaks down conventional lines and allows for collaboration. It was anticipated that the BVSH would act as a beacon, attracting the best and the brightest to Singapore, fostering communities of like-minded individuals, which in turn would draw investment. With world-class talents moving to Singapore, research houses would set up labs at BVSH, thereby creating opportunities for local start-ups to plug gaps in knowledge and services required by major firms.

A MASTER DEVELOPER AND A NEW NAME: ONE-NORTH

> *[JTC was appointed as] the lead agency for the construction of the physical space necessary for the growth of industry in Singapore... one-north fit into JTC's overarching mission of the time: to push boundaries.*[49]
>
> Chong Lit Cheong

With its concept crystallised by the end of 2001, the BVSH was renamed "one-north"—a reference to Singapore's geographic location of one-degree north of the equator. The name change reflected the government's aspiration that one-north's potential be wide-ranging, and not limited to science.[50] Dropping the reference to a "Science Hub" was also aimed at avoiding the perception of the precinct as another business or science park.[51]

A lead agency to coordinate planning and development was crucial to realising the vision of one-north. While the NSTB was the key agency championing the idea of the BVSH, it did not have the expertise to develop it.[52] JTC Corporation, the government agency responsible for the development of industrial infrastructure, was eventually appointed master developer for one-north as, in addition to the requisite domain knowledge and technical expertise, it also had the resources to buy and develop land.[53]

While the appointment of a private-sector developer was considered, it was eventually deemed unsuitable as the government had broader strategic objectives in nurturing the growth of start-ups. These objectives could be compromised because a private developer would be primarily focused on short-term financial returns. Moreover, not only was the size of the project too large for a single developer, its implementation timeframe would be too long for the private sector to stomach. Lastly, there were concerns that the development could be narrowly construed as a property play.

Established in 1968, JTC was tasked with the planning, promotion and development of a dynamic industrial landscape.[54] It played a critical role in Singapore's development by building and managing industrial estates, helping kickstart industrialisation in the nation's formative years. The JTC had gained deep expertise and experience by running numerous industrial projects through their real estate lifecycle—from acquiring land

to constructing factories, to acting as the property manager of completed projects. It had also accumulated experience as a master planner of business parks from its involvement in the Bangalore IT Park in India, and the Suzhou Industrial Park in China.[55] Hence it was tasked with one-north's master planning and development.

Given the evolving nature of manufacturing in Singapore, the JTC was also keen to undertake the role and viewed the proposed activities in one-north as 'new factories' of the future.[56] The district also fitted well with JTC's strategy of pushing boundaries as evinced by its innovative work at the Jurong Rock Caverns and Seletar Aerospace Park. The JTC championed one-north as a development that would create new jobs and new kinds of skills and wealth.[57]

Although the JTC was appointed the master developer, the government also wanted the private sector to be involved in one-north's development. The initial plan was for the JTC to develop only 20% of the precinct in order to kickstart the research hub and generate early momentum. Tony Tan, who then led the Ministerial Committee overseeing one-north, felt that the remainder of the project would be better executed by a more dynamic and innovative private sector. The active engagement of the private sector marked another fundamental shift in government thinking. The JTC would kickstart the project by developing the initial land parcels, with the rest being leased to private developers. Prior to the construction of Biopolis—a cluster focused on biomedical sciences—former JTC Chief Executive Officer Chong Lit Cheong approached CapitaLand, a major local real estate company, to develop it. However, CapitaLand hesitated as it doubted whether the venture would be profitable.[58] Hence, the public sector, through the JTC, seeded the development of one-north.

FORMATION OF ONE-NORTH DEVELOPMENT GROUP AND STEERING COMMITTEE

> *If you want to really create something different in Singapore, you will need to run it very differently...so there was a quite a long debate on how to get this going; who should be driving this.*[59]
>
> Lim Eng Hwee

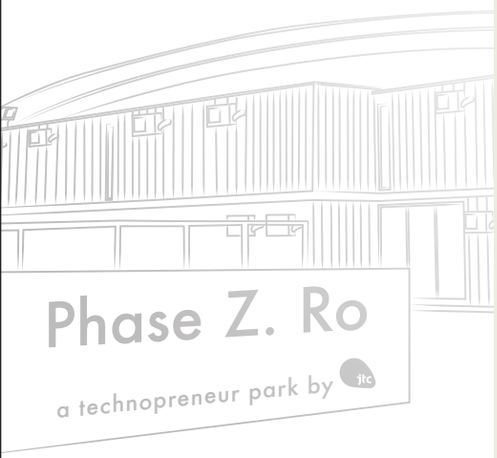
The formation of the one-north Development Group within the JTC gave it the resources to perform the role of a master developer, while also allowing room to break out of conventional thinking. In fact, prior to the formation of the Group, there was a Cabinet discussion on the type of development mechanism needed, and whether the development agency for one-north should take the form of a new statutory board, or be entrusted to either the Urban Redevelopment Authority (URA) or the JTC, given their domain knowledge in building infrastructure and engaging economic agencies.[60]

The Ministerial Committee concluded that to expedite the process, the creation of a standalone unit within the JTC was necessary for taking a fresh approach. The one-north Development Group was formed in 2001 and tasked with working out the nuts and bolts of the new hub.[61] At the same time, the Development Group could draw technical expertise from its 'mothership', the JTC. Insulated from the conventional policies and processes of the JTC, the Development Group could take on a completely new culture. Lim Eng Hwee, a former Deputy Director in the Ministry of Trade and Industry (MTI), recalled that the individuals taking up key roles in the Development Group were "quite different from the rest of the JTC".[62]

Implementing the vision for one-north required experimentation and it was anticipated that the Development Group would need to challenge conventions, push boundaries and introduce regulatory changes. With this in mind, Tony Tan approved the formation of a Steering Committee for one-north, chaired by then Minister of Environment, Lim Swee Say. The Steering Committee—comprising representatives from the MTI, Ministry of Manpower (MOM), Ministry of Education (MOE), NSTB, EDB, JTC, Land Transport Authority (LTA), URA, Singapore Land Authority (SLA), Infocomm Development Authority (IDA), Housing & Development Board (HDB), Singapore Tourism Board (STB) and NUS—would discuss major policy and development issues related to one-north.

The various agencies were expected to contribute to one-north by bringing their unique expertise to the table. The NSTB and EDB came up with the programming of one-north to determine the kinds of enterprises and industries it would attract.[63] The URA, LTA, and National Parks Board (NParks), among other infrastructure agencies, would be consulted on its physical planning aspect. Finally, the JTC would tie the different components together. To ensure close communication between different agencies and allow for quick problem solving, committees were set up at different levels of government. Moreover, instead of following conventional reporting channels, the one-north Development Group reported directly to the JTC CEO and the Steering Committee. Advisory panels were also formed to tap domain expertise from the private sector and international realms (see Appendix A: Implementation Framework for one-north, p. 97).

CATALYSING DEVELOPMENT: PHASE Z.RO TECHNOPRENEUR PARK



Realising that groundbreaking at one-north would only take place at least a year after the announcement of its plans, the one-north Development Group sought to execute a temporary project that could act as a catalyst for technopreneurial activities and as an incubator for technology start-ups.[64] Hence, the JTC developed and managed a makeshift incubation space, named Phase Z.Ro Technopreneur Park.

> *And then we [one-north Development Group] said, "What can we put in place on-site quickly?". Someone in the group suggested an incubator made of portal cabins in the empty lot next to the Ministry of Education building. I said, "Are you serious? As in get start-up companies to work in portal cabins used for construction?" And then it so happened that they designed it in such a way that it looked so funky, despite being cheap and quick. So companies showed up...[and] after a while it had a very healthy community there.*[65]
>
> Goh Kok Huat

Phase Z.Ro was erected on a site formerly occupied by MINDS school, adjacent to the MOE headquarters and close to the Buona Vista MRT station. Launched in June 2001, Phase Z.Ro comprised 60 reused shipping container units stacked two-stories high, with common circulation spaces and shared amenities such as business centres, meeting and training rooms. The Technopreneur Park was to be a temporary site with a three-year lifespan, built at a cost of $4 million. The rental rates of the units were pegged to those at the Ayer Rajah Technopreneur Centre.

Phase Z.Ro Technopreneur Park to catalyse technopreneurial activities and act as an incubator for technology start-ups.
Photo courtesy of JTC Corporation.

Phase Z.Ro gave people and companies the opportunity to come together and collaborate.[66] Tenants mainly comprised start-ups with revenues of less than $1 million in areas such as information technology, electronics, and software.[67] This close proximity was especially important for start-ups as they could feed off each other and find unexpected solutions to problems. Phase Z.Ro was made attractive and affordable to budding technopreneurs through the sharing of support facilities and services. JTC also organised programmes that aided networking with other professionals.[68]

Phase Z.Ro managed to attract a 92% occupancy rate.[69] Its success provided the authorities some comfort in knowing that there was a market for one-north, and that the previously untested concept was feasible, albeit on a smaller scale.[70] By 2008, having served its purpose of acting as a catalyst for one-north's development and a demonstration of its possibilities, the site was taken down and the containers recycled and donated to Singapore Polytechnic.[71]

A SANDBOX EXPERIMENT

The development of one-north—clustering Singapore's biomedical sciences, information and communications, and media industries within state-of-the-art facilities—was poised to be Singapore's next big economic step. Designed with the work-live-play-learn concept in mind, one-north would meet all needs of those who worked there. The complementary range of infrastructure at one-north would not only include laboratories, offices and business space, but also educational institutions, housing, retail outlets and recreational amenities.[72]

one-north was to be a ground-breaking concept, a first in the region not only in terms of its economic functions, but also as a testbed for policy innovations. It was also envisioned as a vibrant area where rules could be relaxed for companies to pilot and testbed. It would create a flagship that people would recognise and associate with when thinking of a research ecosystem in Singapore—ranging from basic research to commercialisation and clustering of start-ups.[73] Led by the JTC, one-north would propel Singapore into a new phase of economic development and grow the economic pie for all. With the development concept of one-north finalised, the next step was to design and implement the detailed plans to bring the vision to reality.

CHAPTER 2

MASTER PLANNING FOR AN INNOVATION DISTRICT

GREATER ONE-NORTH AREA

Aerial view of one-north.
Photo courtesy of JTC Corporation.

The land on which one-north was to be developed had been safeguarded as a potential science park under the 1991 Concept Plan as part of a strategy to develop Buona Vista as a sub-regional centre.[74] The proposed Science Hub would be the centrepiece of a wider knowledge and innovation zone for research and development (R&D), akin to what Raffles Place was to the financial services sector. The district would not only boost the economic value of homegrown industries, it would also attract and cultivate local talent. This investment would have the two-pronged benefit of revitalising Singapore's economic infrastructure along with its human capital.[75]

The innovation district was not planned in isolation. Queenstown, where one-north is sited, has a planning area of 600 hectares (6 km^2) and provides more than 120,000 jobs, accounting for 5% of Singapore's employment. one-north was to be connected with the wider region by creating relationships with the National University Hospital (NUH) and National University of Singapore (NUS), the existing Science Park, Dover, Queensway and the surrounding mature housing estates. There were plans to extend the development belt linking Holland Village as an entertainment area, to Pasir Panjang Village in the south, and further west to the Nanyang Technological University (NTU). In terms of transport connectivity, one-north was to be served by the existing Buona Vista Mass Rapid Transit (MRT) station on the East-West Line and the then upcoming Circle Line. The one-north site is almost equidistant from the city centre and the Jurong Industrial Estate. It is also served by optimal east-west and north-south linkages that form visual and physical barriers across the site.

Planned as a dynamic precinct on the fringe of the city centre, one-north acts as the focal point of the technology corridor stretching from Buona Vista to the NTU. The technology-research ecosystem could then extend outwards, beyond one-north's physical confines and tap the resources of the surrounding institutions, potentially supporting the development of technopreneurial ventures.[76] The district's planning and development were a marked departure from those of typical science parks characterised by sanitised and isolated environments.

MASTER PLAN DESIGN COMPETITION

With the concept of one-north crystallised, an international design tender was mooted by the JTC. The idea of getting design proposals from world-class architects was based on the premise that one-north should look physically different from the rest of Singapore. The JTC's design brief stated that the master plan needed to envisage the district as a ground-breaking and unusual hotbed of science and technology, and that the one-north Development Group was not looking for something conventional. Goh Kok Huat, former Director of the Development Group, recalled that the French word "convivialité", which means "convivial", was highlighted in the design brief to reinforce the need for people to interact.[77]

In fact, the Development Group visited world-famous architecture houses to communicate what Singapore wanted to achieve at one-north, and to attract international interest in the design competition.[78] The competition was design-focused and firms were paid design fees to submit their master plan concepts.[79] A Request for Proposals (RFP) was issued in October 2000. Twenty firms submitted proposals by February 2001, from which the Design Evaluation Advisory Committee shortlisted five.

The tender evaluation was based on a two-envelope approach that first assessed the design and then the price, rather than simply selecting the lowest bid.[80] The five shortlisted submissions were from Zaha Hadid Ltd., Toyo Ito in joint venture with Singapore-based RSP Architects Planners & Engineers, Richard Rogers Partnership, Gensler, and Ellerbe Becket Inc. The JTC then sent teams to the shortlisted firms in Europe, the United States, and Japan to assess them and their projects teams.

Each of the five submissions had their unique strengths, resulting in a stalemate. It boiled down to a choice between what was 'implementable' and what was considered 'visionary'. Broadly divided into 'safe' and 'unsafe' categories, proposals by Richard Rogers and Gensler were considered 'safe' because they proposed utilising planning paradigms that had already been executed in the United States and Europe.[81] However, the selection committee ultimately picked Zaha Hadid's proposal as it best met the stipulated requirements and captured one-north's forward-looking vision.

The abstract and avant-garde master plan submitted by Zaha Hadid, an Iraqi-born British architect known for her radical deconstructivist designs, was not merely a physical plan that was to be followed precisely. It was the concept within the master plan that stood out. She had first looked at old European cities to understand how they were constructed and what made them tick.[82] Drawing out these long-standing principles, she brought the fundamental ethos of old cities to the modern era. The primary focus of the master plan was on people and energy. At a presentation of shortlisted submissions, Hadid described how human energy would flow based on the natural topography of the site. In particular, the JTC liked how her master plan deployed a mix of low-rise and high-rise developments, and provided many opportunities for interesting spaces and settings that would lend themselves to creating a vibrant environment.

ZAHA HADID'S MASTER PLAN FOR ONE-NORTH

Zaha Hadid's master plan created an original urban skyline that is easily recognisable, standing out from the surrounding developments. The usage of a multitude of design features such as alleys, thoroughfares, squares and walkways created multiple unique pockets. Hadid visualised one-north as a space where various human activities would come together, interspersed with greenery and water bodies. Typical ideas related to zoning would be obsolete, allowing people to work, live, play, and learn without boundaries.

Zaha Hadid's master plan for one-north.
Photo courtesy of JTC Corporation.

The proposal interacted with the natural landscape, employing the undulations of the site to give form to the master plan. Proposing an undulating high-density, low-to-mid-rise urban 'envelope' called the 'ground form', the proposal theorised that the real 'energy' of a development lies at the street level. An analogy was made to the older parts of Paris, where buildings are built to the street edge. A web of

curvilinear roads weave through the site, carving out blocks of varying sizes and creating streets and spaces of different shapes and openness, which lend themselves well to hosting street-level activities.

Industry clusters are placed in the most appropriate locations based on detailed analysis of their characteristics and requirements. These clusters serve as incubators for one-north's physical and economic development. In the master plan, the demarcated sites are of different sizes and shapes. However, rather than creating a site that is confusing and difficult to navigate, the gently curving streets and paths allow for an easy understanding of the site. With the three main clusters—later named Biopolis, Fusionopolis and Mediapolis—and the lifestyle portion as a starting point for the one-north concept, the flexible master plan allows planners to react to current changes and make adjustments to meet new demands.

Undulating Building Form

The heights of different buildings are controlled to create a feeling of gentle undulation. This provides a sense of coherence to a viewer from anywhere within one-north. This gentle change in building heights allows structures of different shapes and sizes to be incorporated in the master plan, while a continuous roof carpet brings together the various building typologies and creates coherence on a larger urban scale.

One of the goals of one-north is to have highly vibrant streets to increase the likelihood of chance encounters, potentially leading to the exchange of ideas. Hadid's master plan achieves this by keeping buildings close together to maintain vibrancy at street level. The height of kerbs is reduced to make it easy for pedestrians to cross the road. Deviating from the stipulated setback standards, the master plan has buildings with reduced road reserves and narrow streets. This allows the buildings to provide shelter and shade for pedestrians. The slightly curved roads also funnel air, providing a constant breeze to make walking enjoyable. By creating enclosed and walkable spaces, streets become the main points of interaction. Community life is no longer isolated within buildings and can spill onto the streets to allow the mixing of professions.[83]

one-north Park as a 'Living Room'

> *The living room concept is so important…that's the kind of place for serendipity and community interaction to happen.*[84]
>
> Dr Arthur Aw

Nestled within Zaha Hadid's master plan is the 16-hectare (0.16 km^2) linear one-north Park running through the middle of the district from Biopolis to Wessex. Initially intended to be constructed and maintained by the JTC, the park was conceived as a 'living room' and meant to catalyse community interaction by serving as a focal point for events such as music programmes at night.[85]

In one-north Development Group's discussions with Zaha Hadid, Singapore's East Coast Park was highlighted as a successful case study where the linear-shaped park enabled maximisation of frontage for user access. Additionally, it was observed that park users tended to congregate under shelters and trees instead of sitting in the middle of the park under the sun. Hence, creating a linear park was the best way to maximise the valuable green space within one-north.[86]

one-north Park: Rochester West.
Photo courtesy of JTC Corporation.

The park was eventually developed by the National Parks Board (NParks) and landscaped by urban design and landscape architecture firm, West 8. Taking into account the characteristics of surrounding spaces, it sought to add variety to one-north's landscape and provide visual distinctiveness to its different sections. For instance, one-north Park: Rochester West and one-north Park: Rochester East offer outdoor recreational spots and a brief respite from retail. one-north Park: Rochester West provides an outdoor space near the retail hub of Rochester Mall and The Star Vista, and has been integrated with the open areas within the retail hub, with planter beds full of flowering shrubs and grasses.[87] This contrasts with one-north Park: Fusionopolis North and one-north Park: Fusionopolis South, which emphasise natural ecosystems.[88]

Transportation Network

The master plan spelled out a ring system of Light Rail Transit (LRT) stations, with a catchment area of commuters within 200 metres, weaving through one-north's dense urban fabric. Pedestrian movements would be channelled through interior spaces and sheltered open areas, while vehicles would be limited from entering the site via access permits and systems such as the Electronic Road Pricing (ERP) system. The proposal also studied the 'movement' flows from surrounding neighbourhoods and carved out streets generally along those 'flows', providing a rich option of routes, each with a different experience at the pedestrian level. To better integrate one-north with its surrounding areas, it was proposed to extend the relatively dense street network to those neighbourhoods in all directions.

Flexibility for Future Growth

The proposal linked infrastructure and buildings to existing resources and provided a plan for organic growth based on the three main clusters as catalysts for expansion. The plan allowed for mixed zoning, both horizontally and vertically, with the activities spreading from the various hubs. At the same time, leaving gaps between the hubs would allow for some flexibility in the timing of developments and minimise disruptions to the built site.

The master plan provided considerable flexibility for the future evolution of the site. Following the natural contours of the land, a complex road network was created, which could then be utilised to allow for the natural evolution of one-north. By implementing a non-grid-like system, future developments can be added as needed, with the road network and infrastructure adapting to the needs of the time.[89]

To that effect, there were few key structures in the master plan. The master plan could be constantly reviewed as the site developed, guided by well-defined planning parameters. The base plan and original vision would act as the guiding lights for future action and reviews.

CHALLENGING PLANNING GUIDELINE NORMS

> *I always use one-north as an example [of] how if you are really pushing the boundary...life can really be tough as the force of conventional thinking and wisdom will push back, and you need to buckle up and be prepared for a bumpy ride.*[90]
>
> Goh Kok Huat

While one-north was, first and foremost, to be a place to attract science and technology companies, its planning and development needed to push boundaries and existing planning norms. Zaha Hadid advocated design elements such as narrow streets, smaller land parcels, sharp-edged buildings and reduced setbacks in her master plan, which regulators found hard to accept. The master plan depicted an urban environment typical of European cities, which would have been rejected had it gone through the standard approval process.[91] As one-north's master developer, the JTC used the Steering Committee as a vehicle to push through many ideas.[92]

A bold concept alone would not be sufficient to develop an ecosystem for technopreneurship. It was paramount to have key government agencies such as the Urban Redevelopment Authority (URA) and the Land Transport Authority (LTA) not only participating in the master planning, but, more importantly, believing in and contributing to the vision of one-north. The stakeholder agencies were given leeway to deviate from usual planning rules and development standards in order to experiment with new ideas and policy innovations that could be replicated in future projects in Singapore. With the support of the Steering Committee, the JTC had a free hand in several aspects, including land use, road sizes and typology, planting typology and building setbacks. In effect, one-north served as a testbed for trying out ideas that deviated from conventional planning guidelines.

Non-Standard Road Sections

The road system in one-north differs from the rest of Singapore. Based on the concept of 'designed congestion', a Y-junction was planned at Biopolis with the aim of slowing cars down to facilitate road crossing for pedestrians.[93] To enhance walkability, there are very few four-lane roads. The road widths were also narrowed to make them convenient for people to cross. The one-north Development Group was very clear that the district should not resemble another business park or pavilion-style development, where pedestrians need to walk 25 to 50 metres to get to the next place.[94] Non-standard road sections, smaller than elsewhere in Singapore, were implemented. Traffic calming approaches included using honed granite cobblestones instead of asphalt to pave internal roads within the district to create a safe and walkable environment for pedestrians.

Narrowed road widths and honed granite cobblestones at Biopolis as traffic calming measures.
Photo courtesy of JTC Corporation.

Reduced Building Setbacks

Guidelines for setbacks were relaxed and the buildings within Biopolis were built right up to the edge of the road, with no setbacks, in order to keep the structures close together.[95] This would not only create shaded and walkable streets suited to Singapore's tropical weather, but also ensure vibrancy.[96] The green buffer between roads and buildings was also kept minimal. In planning terms, it was almost 100% site coverage in terms of envelope control, or regulation of the building façade.[97]

Introduction of 'White Use'

Another breakthrough was the application of 'white use' at one-north, which required the Steering Committee's approval. Typically, in Singapore, a 'white' site is a plot where a range of uses is allowed, although very often the URA will stipulate a minimum component of a specific use to meet its planning objectives.[98] However, the unpredictable nature of the innovation community that one-north was meant to attract made it difficult for authorities to predict the land functions required, rendering the URA's 'white use' zoning policies irrelevant.[99]

According to Dr Arthur Aw, former Deputy Director of the Development Group, the URA's notion of 'white use' in the city centre has little to do with the master developer's ability to influence the proportions of different land uses. Instead, it has served as a land valuation approach to let market forces determine the land use that would create the highest commercial value. Instead of being innovation-driven, it is driven by real estate values.

In contrast, the one-north Development Group wanted to champion a different approach to 'white use'. This meant giving the master developer the ability to change the mix of the 'work' and 'live' components. After several rounds of negotiation with the URA, it was decided that while a mixed-use proportion was allocated to each land parcel, the overall mixed-use proportion within the entire one-north district could be adjusted. In the official master plan, the land use zoning for one-north would be indicated as 'reserved use'. This flexibility in zoning enabled the proportions of different land uses to be adjusted at different phases according to demand.

Provision of Affordable Housing

In the overarching master plan, the idea of providing residential uses in the form of affordable housing was put forth to achieve the work-live-play-learn vision for one-north. At the initial stage, the JTC tried to work with the Housing & Development Board (HDB) for the provision of affordable housing in the district. However, it was difficult for the HDB to change its public housing policies for a single project like one-north.[100] Therefore, the

JTC approached the private sector. This led to the completion of one-north Residences in 2009 by Vista Development Pte Ltd. Comprising 405 units, the condominium is the first fenceless private residential development in Singapore, allowing public access to its outdoor plaza and retail outlets located on the ground floors of the apartment blocks.[101]

Plaza and ground floor retail outlets at one-north Residences.
Photo courtesy of JTC Corporation.

However, with a property boom in the late-2000s, and a surge in housing demand, prices of the newly built one-north Residences shot up, rendering the idea of affordable housing by private developers untenable. Similarly, when The Rochester, comprising 334 units, was launched in 2011, housing prices remained high. As a result, the JTC halted all private tenders until the pricing mechanism could be sorted out.[102] It held back releasing more land for residential developments in one-north amid concern that developers were bidding up land prices in an overly exuberant property market.[103]

Translating Plans into Reality

The key concepts of Zaha Hadid's master plan, coupled with the unconventional planning parameters championed by infrastructure agencies provided one-north with a unique solution to overcome urban restrictions in Singapore. As soon as the formulation stage was completed, the detailed planning and construction of Biopolis Phase One began. The construction of Biopolis Phase One had to be completed within a short period of time so that it could act as the vanguard for Singapore's transformation to a technopreneurial economy. Hence, phase one of Biopolis took only 18 months from groundbreaking to tenant occupancy.

CHAPTER 3

BIOPOLIS: A FRONTIER FOR BIOMEDICAL RESEARCH

> The Biopolis is special because it is an industry unlike any other—not manufacturing, wafer fabs, or electronics, but research. The clustering brings together public and private research, and the educational institutes. It brings together a community. If it succeeds, it does so as a community. This is the start. The Biopolis is one seed, the rest will germinate and together they will grow.[104]

Philip Yeo

Breaking ground in 2001, Biopolis was the first cluster to be built in one-north. The one-north Development Group faced much pressure to lead the joint inter-agency effort to complete phase one of the precinct. Phase Z.Ro had successfully achieved its mission of showing that there was sufficient talent and innovation in Singapore to sustain a dynamic and thriving community of start-ups.[105] Biopolis would build on that success, demonstrating to the world that Singapore was ready to invest heavily in what it considered to be the future of its economy.

The construction of Biopolis involved building research labs that would attract what Philip Yeo, former Chairman of the National Science and Technology Board (NSTB), called the 'big whales'—world-renowned scientists who would in turn attract other talent and expertise needed to grow Singapore's biomedical scene. Compared to established technopreneurship hubs such as the Chapel Hill Research Triangle, it was crucial to identify Singapore's competitive advantage.

Groundbreaking of Biopolis on 6 December 2001 by former Minister for Trade and Industry, George Yeo (middle), Philip Yeo (left) and Lim Neo Chian (right).
Photo courtesy of JTC Corporation.

The intention behind locating an entire research and development (R&D) value chain in close proximity was to encourage unexpected connections that could form the basis for new commercial propositions, helping cement Singapore's position as a rising hub for biomedical sciences.[106] It would act as a place where local talent could interact with international researchers, seeding the way for the development of Singapore's R&D capabilities. Biopolis would also serve a larger national goal by acting as a focal point for the efforts of the Economic Development Board (EDB) and the NSTB to attract new investments in the pharmaceuticals and life sciences sectors.

PUSH FOR RESEARCH IN BIOMEDICAL SCIENCES

The NSTB was tasked with formulating and implementing long-term R&D strategies for Singapore.[107] Since the mid-1990s, the NSTB had been pursuing the idea of setting up research clusters to attract technology companies to Singapore. By 2000, the key industries driving Singapore's economy were petrochemicals, logistics and precision engineering. The biomedical sector was Philip Yeo's pet project. He recognised the industry's growth potential and convinced the government to invest in it.[108]

As the Chairman of the NSTB in 2001, Yeo was tasked with the development of the biomedical cluster.[109] The NSTB realigned its focus to two key areas: biomedical sciences research and the development of human capital to drive it. That year, the NSTB was restructured to form the Agency for Science, Technology and Research (A*STAR), and tasked with advancing the nation's R&D capabilities and human resources.

Biomedical research and development hub in Biopolis.
Photo courtesy of JTC Corporation.

Biomedical sciences study cells, organs and systems in the human body, leading to the understanding and treatment of debilitating diseases. Singapore hoped to develop an industrial cluster focused on these, pushing the frontiers of healthcare and public health. The aim was to transform science from an educational to an economic endeavour serving national interests.

This endeavour had several benefits. With major pharmaceutical companies such as GlaxoSmithKline already manufacturing drugs in Singapore, the addition of their research arms would not only bring in upstream jobs, it would also further tie these medical giants to the country and indirectly protect jobs. Research institutes based in Singapore would also produce intellectual property that could help to create and support local companies. One example of this is Hyflux's Kristal hollow-fibre ultrafiltration membranes used in water purification that helped to differentiate the company from its competitors. The development of the biomedical sector would improve the health of Singaporeans in the long term. With groundbreaking research eventually moving on to clinical trials, Singaporeans would have first access to medical advances that could save lives.[110]

After studying the profiles of various R&D institutes, the A*STAR felt that in order to attract biomedical companies, Singapore would need to create a space that catered to their needs. This development coincided with the initial conceptualisation of one-north, resulting in the birth of Biopolis as the first high-value-added cluster for biomedical research in the estate.

BIOPOLIS: FROM 'BENCH TO BEDSIDE'

The name 'Biopolis' was conceived by Yeo as an amalgamation of the words 'biomedical' and 'polis', an ancient Greek term for a city of about 20,000 people. The name was apt for what would be a mini-city built to create a biomedical sciences research ecosystem—from discovery to clinical trials and commercialisation.[111] The basic idea behind Biopolis was to bring innovations from 'bench to bedside', making the jump from basic to translational research that turns ideas into concrete ways of saving lives. The whole life cycle—from R&D to commercialisation—would be housed at Biopolis.

Tailored to be the leading research hub for biomedical sciences, Biopolis sought to cluster top-tier public and private biomedical organisations and research institutes under one roof. At the time of its conception, this new model had yet to take root elsewhere.[112] By bringing together the full spectrum of biomedical activities and resources, scientists could mingle closely, allowing for the cross-fertilisation of ideas.[113]

To foster collaboration and innovation, Biopolis was designed to be human-centric by making the amenities and facilities that researchers needed as comfortable, convenient and pleasant as possible. These ranged from cutting-edge research labs to food and retail options, creating an all-encompassing village that met all the needs of researchers.

Public spaces in Biopolis.
Photo courtesy of JTC Corporation.

Zaha Hadid's master plan also set a high bar in terms of what could be conventionally accepted as a research hub. The one-north Development Group had to tear down stereotypes of what a building that housed laboratories should look like. They had to convince policymakers that an unconventional compound like Biopolis was the right fit for Singapore's biomedical industry.[114] For example, it was rare for a single complex to house clean-room laboratories alongside a host of different biomedical research facilities.[115]

Despite some deviations to Hadid's master plan in order to meet practical considerations of building efficiency, or percentage proportion of building's rentable area, Biopolis was the cluster that remained most true to her blueprint.[116] Inspired by medieval European cities, Biopolis was built to be compact, with narrow streets separating buildings, making the streets public spaces for community interaction.[117] Its design challenged the typical planning standards set by various government agencies in Singapore—a factor that made the broader one-north master plan difficult to implement.

DESIGN ELEMENTS OF BIOPOLIS

Zaha Hadid's design for Biopolis included five crucial elements.

Low-Rise, High-Density Buildings

Built with street-level connectivity in mind, the buildings in Biopolis were planned to be low-rise but dense, with envelope controls that were not based on the conventional squares or rectangles. The resultant sharp-edged buildings faced objections from several quarters, with criticisms ranging from inefficient layout to 'bad fengshui'.[118] Despite these objections, the one-north Development Group managed to convince stakeholders of the merits of the design. The average height of the buildings was 10 storeys, but certain strategic sites could feature taller buildings.[119]

Biopolis was to house the best bio-containment facilities, stem cell banks, and wet and dry labs to entice major names to work there. The cost of expensive specialty engineering and process equipment, as well as the supply and disposal of raw materials, was lowered through economies of scale. By tapping on shared gas tank farms, and biohazard or toxic waste removal facilities provided by third parties, individual research labs no longer needed to buy expensive equipment that they would only use occasionally. Instead, they could simply book a time slot to use the shared equipment.

Innovation in Environmental Sustainability

The one-north Development Group looked for ways to spearhead innovation in environmental sustainability.[120] Biopolis would serve as a testbed for promising environmental technologies. This included a building-integrated photovoltaic (PV) system to validate the cost effectiveness of clean energy.

As the lead development agency for one-north, the JTC could push through ideas that had not taken off for want of critical mass. One such example is one-north's district cooling system. The greenfield site selected for the development of one-north was well vegetated and generally one degree cooler than the rest of Singapore.[121] An underground district cooling system located below Biopolis, and owned by Keppel DHCS,

provided centralised cooling to optimise the use of space, reduce energy consumption for air-conditioning, and lower operating costs for users. Allowance was also made for future expansion to the rest of one-north.

Intelligent Building Automation Systems were also deployed to optimise energy use. A Pneumatic Waste Conveyance System created a cleaner and more pleasant living environment. Recycling collection points were also incorporated into the design.[122] Other innovative environmental technologies that were in use as early as 2004 included robots for cleaning building façades, fuel-cell cars and personal transporters.[123] Biopolis was awarded the Building and Construction Authority's Green Mark Gold in 2005 for being an exemplary showcase of promising environmental technologies.[124]

Preservation of Mature Trees

> *It is cool sitting below a tree in the open. [But] if you remove the tree, [then] to experience the same cool feeling we need 10 air conditioners blowing at you in the open.*[125]
>
> Chong Lit Cheong

One of the JTC's requirements was to retain as much of one-north's original flora and fauna as possible.[126] To create a 'worn in' feeling right from the start, big mature trees that were present on the site were removed during the construction phase and replanted once the buildings were completed. Many of these were replanted in Biopolis, becoming "instant trees". With mature trees along the heart of the development, Biopolis instantly took on a lush urban design. The natural effect of having these trees was further accentuated with man-made improvements. Hidden pipes running up the trunks could sprinkle water from above and lights hidden among the leaves created a magical atmosphere at night, as if fireflies were nestled within Biopolis.[127]

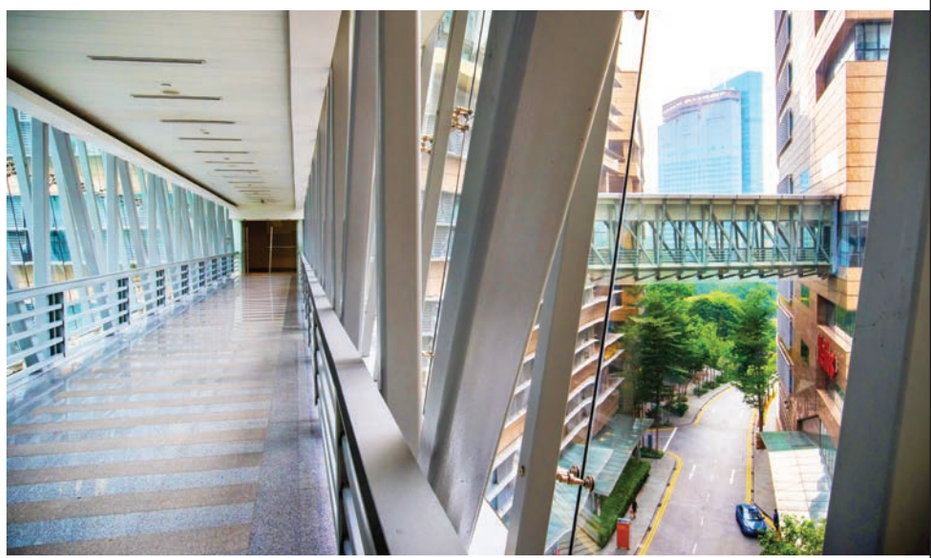
Design of Road Sections

As the roads and gaps between buildings were to serve as communal spaces and facilitate interaction, the architects strived to make them as conducive as possible to attract people to use them. The ground level of strategic areas were lined with food and beverage (F&B)to entice people to slow down and use the spaces.[128] The angles of buildings in relation to each other, as well as their close proximity to the surrounding buildings, made clever use of wind tunnel movements to effectively cool the public spaces, creating a conducive outdoor environment for walking and resting.

The roads in Biopolis also have half kerbs that are lower than standards required by the Land Transport Authority (LTA). This was designed so that people could step onto the road without encountering obstacles, allowing for horizontal interaction.[129] Such small design touches came together to facilitate the ease of movement throughout Biopolis.

Primary and Secondary Linkages

While the street level of Biopolis was made conducive for pedestrians, sky bridges connecting its initial seven buildings facilitated secondary connections for the convenience of people working there. The sky bridges protected people from the elements and helped to ensure that the buildings would not become silos. The intention was for the buildings to work as an inter-connected mesh facilitating linkages between the various institutes, making movement between buildings as easy as between the floors of individual towers.[130]



Secondary linkages between buildings in Biopolis.
Photo courtesy of JTC Corporation.

RESOLVING INTER-AGENCY DISPUTES VIA THE STEERING COMMITTEE

With stakeholder ministries and agencies represented on the Steering Committee, it played an important role as a 'dispute-resolution body' that had the final say in settling inter-agency conflicts. The involvement of the relevant ministries and agencies from the outset was crucial because what was to be built at one-north would be maintained by the respective infrastructure agencies.

In particular, to ensure design coherence with its immediate surroundings, the exterior of one-north would have to follow the urban design guidelines set by the Urban Redevelopment Authority (URA). In the initial phase, the JTC and the URA disagreed over the demarcation of areas that would come under the JTC's jurisdiction.[131] In response to the JTC's proposal, the boundary of one-north's core area was extended to include a triangular parcel of vacant land at the junction of Ayer Rajah Expressway (AYE) and Buona Vista Road, as well as a parcel that currently houses the headquarters of the Ministry of Education.

Former JTC Chairman Lim Neo Chian recalled that the agencies also differed over the quantum of commercial space at one-north. The URA was concerned that allowing too much commercial space there could undermine developments in other areas such as Holland Village. On the other hand, insufficient commercial space could jeopardise one-north's work, live, play and learn concept.[132] Eventually, it was decided that retail and F&B space contribute to 2.87%, or 110,000 m^2 gross floor area, of one-north's total quantum.[133]

WESSEX AND CHIP BEE GARDENS

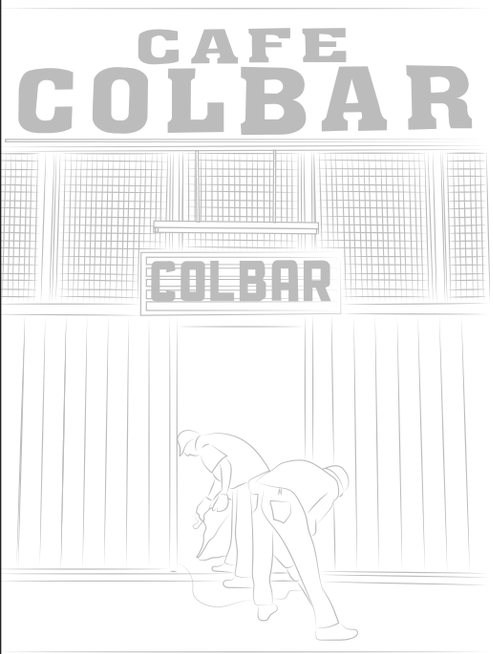
In the initial period leading up to completion of Biopolis, it was necessary to ensure various housing options were available to its workforce within and in close proximity to one-north. With that in mind, Wessex, which lay within one-north, and the nearby Chip Bee Gardens were identified for adaptive reuse. Both were state properties and offered colonial-era apartments and houses.

In late 2004, the JTC assumed ownership of Wessex to refurbish it to provide housing for the working population of creative industries located within walking distance in one-north.[134] The units, consisting of colonial-era walk-up apartments and semi-detached houses, were converted into work lofts, home offices and home studios to foster a creative community in the arts and culture.[135]

Wessex @ one-north.
Photo courtesy of JTC Corporation.

Similarly, the JTC was appointed master tenant of the 15-hectare (150,000 m^2) Chip Bee Gardens in July 2002 by the Singapore Land Authority (SLA).[136] Chip Bee Gardens—comprising 349 terraced houses, 40 apartments and 20 retail shops—was established in 1950s to house members of the British Army and their families.[137] Former JTC CEO Chong Lit Cheong noted that the estate was strategically positioned to attract scientific talent to fuel Biopolis' growth by offering a variety of lifestyle options to complement one-north's conducive work environment.

THE REMAKE OF COLBAR



Located in the Portsdown Road area, Colbar ('Colonial Bar'), is an eating house that opened in 1953 and functioned as a British Army canteen. Serving mainly the residents of Wessex, Colbar has been an iconic watering hole patronised by people living and working in the area. Originally located in a single-storey two-room building along Jalan Hang Jebat, Colbar embodied the spirit the area known as 'Little Bohemia'. Seated on plastic chairs, customers would shoot the breeze, debate history or simply chill.[138]

As development work in the area intensified, a new 1.1 km road linking Queensway to the AYE was proposed in 2002 to help cut the travel time from 10 minutes to three. The new road was needed as the traffic was expected to increase with the development of one-north.[139] The 50-year old Colbar, along with the residents of the Portsdown area, an old tailor shop and car workshop, lay in the way of the new road.[140] Colbar's impending demolishment was met with an outpouring of emotion from residents past and present.[141] To them, the eatery represented the community. Colbar served its last meal at its original location on 17 July 2003.[142]

Colbar: A local landmark in Wessex.
Photo courtesy of JTC Corporation.

> *My colleague [who] was looking after [the relocation of Colbar] said he told the contractor, 'I want you to recreate Colbar as closely as possible to the original.' So they reused all the material, [but] some of the things like tiles, they had to put in new ones. One day, the owner went to Colbar and saw the contractor cracking some tiles with a hammer and [asked]: 'What are you doing?' The contractor said, 'You said you wanted it exactly like the old one? So I'm giving you exactly like the old one, including the cracked tiles!'*[143]
>
> Andrew Ho

As calls to conserve Colbar grew, the JTC began working with the LTA and residents of the Portsdown area to look at ways to preserve Colbar's unique ambience.[144] The one-north Development Group initially suggested that the LTA consider diverting the new road to preserve the original Colbar. When that proved impossible, the JTC decided to physically relocate the building to preserve it as a local landmark. Much of the material from the original building that could be reused was utilised in the reconstruction, which cost $120,000.[145] Colbar was back in business in six months—a familiar building on new ground.[146,147]

THE MAKING OF BIOPOLIS

Biopolis was originally intended to be located nearer to the National University Hospital (NUH) and the National University of Singapore to better foster synergies with them. However, there were compelling reasons to build it closer to the Buona Vista Mass Rapid Transit (MRT) station.[148] Good connectivity and access to public transport were important for attracting a scientific workforce. As the first research hub at one-north, Biopolis' success was crucial for spurring subsequent developments in the district.

While constructing a project of the magnitude and complexity of the first phase of Biopolis would have normally required at least two years, with another six months for internal outfitting works, its first three blocks were completed fully in just 18 months.[149] However, Hadid felt the time frame was too short and declined to act as the primary architect of Biopolis. Instead, she preferred to play a secondary role of advising on the master plan and design of Biopolis and its buildings. Hence, the one-north Development Group engaged JTC International Holdings, a JTC unit specialising in providing master planning and engineering services for industrial developments. It retained Hadid's original building envelope design and carried the key themes and ideas of her master plan. [150,151]

The one-north Development Group worked on multiple fronts to build the district within the stipulated timeframe. Its task was further complicated by the need for lengthy negotiations to obtain exemptions from several planning norms and conventions that one-north challenged. Construction works started even as the master plan was being finalised, a process that a former director of the Development Group called "concurrent engagement".[152] Construction continued almost round the clock, seven days a week. For four months after the groundbreaking ceremony in December 2001, giant excavators transported 500 truckloads of soil daily from the one-north site to create a basement three-storeys deep.[153] Unlike the typical approach of levelling the site before starting construction, careful ground measurements were taken before excavation began so that the site's natural contours could be reconstructed in accordance with the master plan.

The construction was carried out in five phases. Phase one focused on the Chromos, Centros, Matrix, Genome, Proteos, Nanos and Helios buildings, and was completed in October 2003 at a cost of $500 million. Of the seven buildings, which span 185,000 m^2, five are occupied by A*STAR's public research institutes, and two are multi-tenanted. By 2006, phase one enjoyed more than 95% occupancy.

Phase two of Biopolis saw the construction of the Neuros and Immunos buildings to house private research institutes, and was completed in October 2006. The JTC awarded the concept price tender to a private developer, Ascendas (Tuas) Pte Ltd.

Phase three was completed in November 2010 by another private developer, Crescendas Bionix Pte Ltd. Comprising two buildings—Synapse and Amnios—it added another 41,000 m^2 of research space. The multi-tenanted research facility was intended to extend basic research activities to translational and clinical research, as well as medical-technology research.[154]

In 2013, Biopolis marked its 10th anniversary along with the completion of phases four and five. Phase four brought an additional 32,000 m^2 of space in the form of multi-national company Procter & Gamble's Singapore Innovation Centre. Phase five introduced Nucleos, a 46,000 m^2 space to be used for pre-clinical trials.[155]

Procter & Gamble's Singapore Innovation Centre further bolstered Singapore's medical-technology industry. The laboratory designs for the buildings were adjusted based on the JTC's experience with research labs constructed in the first three phases. Fitted-out spaces were customised with the required laboratory facilities to allow companies to start operations expeditiously. With the completion of phases four and five, Biopolis was equipped to serve cutting-edge medical laboratories.[156]

FOCAL POINT FOR BIOMEDICAL AMBITIONS

A key factor in the development of Biopolis was that the focus was not on maximising the financial value of land. Instead, the government wanted Biopolis to be the focal point of Singapore's ambitions for the biomedical sector. The urban solutions implemented were tools to create a space that was conducive to research and innovation.[157]

The JTC acted as the master developer and landlord of Biopolis, while the A*STAR led the way by becoming Biopolis' anchor tenant.

This assured the JTC that Biopolis would not lie vacant.[158] Through one-north, the JTC was also able to extend its traditional role as a developer and owner of industrial space to include offices, ensuring its continued relevance to Singapore's evolving economic landscape.

Biopolis currently houses approximately 2,000 PhD research scientists, complemented by the training of another 1,000 PhD scholars funded by the A*STAR, allowing local and international talent to interact.[159]

CHAPTER 4

FUSIONOPOLIS: SYNERGISING SCIENCE AND ENGINEERING

Just as Biopolis served as a focal point for developing new capabilities and attracting investments in the pharmaceuticals and life sciences sectors, Fusionopolis was conceived as a hub for information and communications technology (ICT), media, physical sciences and engineering. It would be the next step in the evolution of Singapore's ICT capabilities, catalysing a shift towards a more collaborative culture by bringing together researchers from different fields and producing novel results.

Creative destruction—a term coined by Austrian-American economist Joseph Schumpeter to describe a process of industrial mutation that destroys old economic structures to create new ones—was important for the next stage of Singapore's evolution into a knowledge-intensive economy. Tan Chin Nam, former Permanent Secretary in the Ministry of Communications and Information and past Chairman of the one-north Resource Advisory Panel, noted that in Singapore's context, creative destruction meant doing something fundamentally different to bring about the integration of various capabilities in order to achieve a higher level of performance.[160]

Salient examples of such creative destruction and cross-fertilisation of ideas between science and engineering came from the Campus for Research And Technological Enterprise (CREATE), an initiative of the National Research Foundation (NRF) to bring together diverse talents from different world-renowned universities on a single campus located in one-north.

These included multi-disciplinary collaborations to develop a device to detect and capture tumour cells circulating in the bloodstream before cancer develops. In addition to biological expertise, mechanical engineering brought to bear the ability to differentiate the stress and strain levels of different cells to detect and isolate the tumour cells.

In another instance, a professor on the campus designed an antibody using a novel approach. Instead of adopting a biological point of view to identify the surface proteins of viruses that can readily mutate, the professor examined the virus from an engineering perspective to study its energy consumption. He developed an algorithm to examine where the virus consumed the most energy in order to identify its core, which would be less susceptible to mutations, before studying the biological structure to design the antibody. By turning conventional biological thinking on its head, he was able to design the antibodies within two weeks, enabling the first dosing of humans against the Zika virus in an unprecedented timeframe of nine months.[161]

Fusionopolis was named to reflect its aim of encouraging the fusion of ideas by clustering a community of knowledge workers from the ICT and media industries, physical sciences and engineering in a dynamic space.[162,163] The cluster would tackle problems that required a fusion of different skills and capabilities. By bringing together experts from different but interrelated fields, multi-interdisciplinary research institutes located in Fusionopolis would be able to take an integrated approach to problem solving.

Fusionopolis One located above one-north one-north Mass Rapid Station (MRT) Station.
Photo courtesy of JTC Corporation.

The high occupancy rates at Biopolis showed that such a research hub was viable in Singapore and drew in private developers. Notably, four developments in Fusionopolis—Solaris, Nexus @one-north, Sandcrawler and Galaxis—were developed by the private sector. The JTC continued to act as the master planner and landlord, as well as developer for Fusionopolis One and Two. Additionally, Fusionopolis also benefited from involvement of the Agency for Science, Technology and Research (A*STAR) and research bodies such as the Institute for Infocomm Research (I2R) and Science and Engineering Institutes (SCEI).

DISSOLUTION OF THE STEERING COMMITTEE AND ONE-NORTH DEVELOPMENT GROUP

Since the idea of one-north was first mooted in 1999 under the Technopreneurship 21 (T21) programme , there had been a shift in its development strategy. By 2006, the district's development process had stabilised to an extent that there was no longer a pressing need for high-level representation on the Steering Committee, according to Andrew Ho, former Senior Principal Planner, Planning and Design at the one-north Development Group.[164] Hence, the body that had thus far been instrumental in challenging policy norms and resolving inter-agency disputes was dissolved by 2006.[165]

The JTC, which had spearheaded one-north as its master developer, refocused attention on its core competency of industrial planning and development. With attention shifting back to the development of business parks, residential components in the JTC's portfolio, such as those in one-north, were de-prioritised. Philip Su, JTC's former Assistant CEO, noted that the organisation's involvement in one-north also led to a subtle shift in the perception of the district, from that of a national project to one driven by the JTC.[166]

> *When we have a development branded as a national project, the stakes will definitely be higher. At this level, we will be able to better mobilise the nation's resources and attract worldwide interests for strategic alliances to drive its success internationally. We should expand and not limit the interests and potential of such a project to that of a statutory board's initiative.*[167]
>
> Philip Su

With the one-north Development Group disbanded by 2006, its functions were integrated within the JTC's respective industry units. Lim Neo Chian, JTC Chairman from 1998 to 2003, said: "One of the elements that we were very conscious of when we started one-north, [was] that we have a separate planning team to consider fresh perspectives to planning and development issues, and pioneer new approaches. Now...it got absorbed back into the JTC".[168]

After 2006, following a strategic review by the JTC, the focus on one-north shifted from the value chain to clusters such as biomedical sciences and electronics, infocomm media and start-ups. Instead of a dedicated team focusing on one-north holistically, different JTC teams began looking after various aspects of it as part of their respective industrial clusters. Subsequently, a new one-north development team was formed in 2015 under the JTC's New Estates Division, which oversees the development, programming and implementation of place making strategies for one-north.

RETAINING AN IDENTITY WHILE REVERTING TO PLANNING NORMS

Following the change in strategy for one-north, conventional planning norms such as standard road reserves and roadside tree planting requirements re-surfaced overtime. Some of the initial drawings were regularised, leading to wider roads and more regular plots.[169] In view of the changes, Zaha Hadid's malleable master plan came handy as it allowed JTC to change the physical fabric of the site to meet the evolving needs of industries. However, this meant that Fusionopolis would look very different from Biopolis.

> *When the team composition changed, it could be felt that [the attitude shifted to one of], 'Why push so hard? Why go and disturb other people? Just follow the standards [and] don't make things difficult for everyone'.*[170]
>
> Andrew Ho

Changing external circumstances also influenced Fusionopolis' development. The emergence of global terrorist threats meant an increased likelihood of high-profile areas such as one-north being targeted, and security issues came to the fore. As a result, the barrier-free environment originally envisioned could no longer be realised without major compromises. Hence, Fusionopolis was built with road designs and barriers typically found in Singapore.[171]

This meant that the urban fabric of one-north would have to keep pace. Having plots within one-north designated as 'white sites' would once again prove useful, allowing developers to respond dynamically to market needs.

The distinctive elements of Hadid's original master plan that can be seen in Biopolis were absent in Fusionopolis, which was based on a different grid system.[172] Unlike the smaller and more fluid development plots envisioned in the master plan, the parcellation of plots in Fusionopolis was larger and regularised, imparting a look and feel that was closer to a typical office complex. However, some of Hadid's key planning principles did prevail. Dynamic mixed use, seamless connectivity, constant rejuvenation and a unique identity remained key concepts throughout one-north, as did the idea of fenceless buildings.

Fusionopolis also developed its own identity, with the land plots and roads taking direction from the site's natural topography. Fusionopolis was envisioned as a vertical city with a high-density and integrated mixed-used layout. Fusionopolis One features Symbiosis as well as Connexis North and South standing at 22, 24 and 21 storeys, respectively, soaring above other relatively low-rise developments in one-north.[173]

The roofs of surrounding buildings were designed such that they would gradually ascend as they move closer to Fusionopolis. The interlinkages in design can be seen from the curved sloping roofs that come together to create a dramatic and coherent silhouette.[174]

While Fusionopolis and Biopolis were built at different stages, plots of vacant land were set aside between the two hubs to allow future phases of one-north to be added between them organically.[175]

ENHANCING CONNECTIVITY

Realignment of the Circle Line

The Circle Line of Singapore's Mass Rapid Transit (MRT) commuter train network was originally planned to run along North Buona Vista Road. However, the one-north Development Group convinced the Steering Committee to get it shifted eastwards so that the underground one-north station would be located at the current site of Fusionopolis One. Dr Arthur Aw, the Group's former Deputy Director, noted that the major rationale for the realignment was to discharge commuters right into one-north's key nodes, and to create a transit-oriented development (TOD).[176]

Although locating the MRT station along North Buona Vista Road seemed to be the easiest and cheapest solution, additional physical links would have had to be built to bring people to one-north. Dr Aw recalled that while he tried to convince the steering committee to move the MRT line inwards, there were concerns that this would limit the development potential of land around the proposed station. However, Dr Aw felt that the limitation could be addressed by increasing the density of land located immediately next to the station, as well as planning a series of active public areas in zones where building heights were restricted to two storeys.

In terms of transportation systems, one-north was quite forward-thinking during its formative stage. A car-free zone as well as transportation links to the Central Business District (CBD) and Changi Airport were deemed crucial for development of a technopreneurial environment, noted Teo Ming Kian, former Chairman of National Science and Technology Board (NSTB).[177] Trams and personal mobility devices were also proposed to augment the MRT network.[178] An early narrative submitted to the Cabinet—imagining what it would be like to work, live, play and learn at one-north—even envisaged an air terminal directly linking one-north to Changi Airport via an MRT line.

People Mover System for one-north

To augment the one-north MRT station, there were initial plans for an efficient all-weather People Mover System (PMS) linking various places within one-north, as well as the nearby Science Parks, National University Hospital (NUH) and National University of Singapore (NUS). While the underground Circle Line would operate at high speed with one stop in the district, the PMS would run at a slower speeds and accommodate more stops.[179] Former JTC CEO Chong Lit Cheong said: "We want people to interact horizontally...[not] vertically...We were very fascinated with trams because trams bring in that kind of horizontal interaction...[that's why] the original master plan had a tram [system] in mind."[180]

However, a Light Rail Transit (LRT) system was preferred to trams. The proposed LRT was to form one-north's transportation system, facilitating movement and interaction among residents, workers, researchers, technopreneurs, students and visitors. Furthermore, it would also substantially enhance the value of the surrounding state land.[181]

However, there was neither the critical mass to justify building infrastructure for the PMS, nor was it deemed financially viable for the government to subsidise the operating losses of the proposed LRT system.[182] Hence, a dedicated feeder bus service serving one-north emerged as the more viable option.[183] While the absence of a PMS might have contributed to the lack of integration between the different areas of one-north, emerging technologies such as electric and autonomous vehicles may help to strengthen such connectivity in the future.[184] In 2016, the JTC introduced the one-north Rider, shuttle bus service catering to the needs of commuters within one-north.[185]

THE MAKING OF FUSIONOPOLIS

In response to market demand, Fusionopolis was to be built in five phases over 15 years. When completed, the complex would provide Singapore an iconic infocomm, media, physical science and engineering cluster spanning more than 30 hectares (300,000 m^2).[186]

Fusionopolis Phase One

Designed by renowned Japanese architect Kisho Kurokawa, Fusionopolis One comprises two unique composite steel and concrete towers, Connexis and Symbiosis, which are more than 20 floors high and are linked by a ground-floor podium.[187,188] Yielding 120,000 m^2 of space, it provides the infocomm and media industries a work, live, play and learn environment. The complex is located directly above one-north MRT station, with an internal link to the station.

The development serves as a focal point for test-bedding the latest technologies in infocomm and media, environmental technology and construction.[189] As the first mixed-use development in one-north, it features a theatre, serviced apartments, 13 public sky gardens, leisure facilities as well commercial outlets. Fusionopolis One branded itself as a prototyping facility, providing a unique opportunity for companies to testbed products and services.[190]

Innovative building techniques were employed in its construction, with the super column construction method being used for the first time in Singapore. A single central super column, rather than multiple beams, would hold up the floor plates. Construction was so precise that, once completed, the super slabs settled within 15mm of their design specifications.[191] Its central core containing utilities and elevators hold the weight of the floors. Steel structures are laid every five floors to support the weight of the five floors resting above them, rather than spreading the weight to other steel slabs. Attachments such as the outside ‘skin’ of the building provide stiffness, but not weight-bearing capability.

Unlike other skyscrapers, Fusionopolis One does not sway back and forth in the face of strong winds. Instead, the buildings ‘gyrate’ because of the skywalks that link the towers—the top and bottom of the towers remain in place while the middle wobbles in a circular motion.[192] Fusionopolis also integrates Intelligent Building Automation Systems to improve performance of the structures’ engineering systems and optimise energy usage.[193] The complex was awarded the Structural Steel Design Award in 2007 for its creative use of steel.[194] It also clinched the BCA Green Mark Gold Plus Award in 2012. Like the work that would take place within Fusionopolis, its construction required a deep understanding of engineering principles and material properties.[195]

Fusionopolis Phase 2A

Construction of an additional 103,600 m^2 of floor area in Phase 2A began in December 2006 at a cost of $250 million.[196] In its tender for the construction of the site, the JTC stated that it was to be a node “that will nurture a vibrant research community”.[197] Spread over 13,000 m^2, Fusionopolis Two comprises three buildings—Innovis, Kinesis and Synthesis—that house dry and wet laboratories, district cooling plants, ground floor retail units and clean-room facilities to cater to the needs of research institutes.[198]

Fusionopolis Two: Innovis, Kinesis and Synthesis.
Photo courtesy of JTC Corporation.

The A*STAR's research arms—Institute of Microelectronics, Institute of Materials Research and Engineering, and Data Storage Institute—and the Singapore Institute of Manufacturing Technology were brought in as anchor tenants to maximise the use of the inter-disciplinary laboratories and state-of-the-art facilities.[199] More than half the space in this phase was taken up by the A*STAR, allowing it to consolidate its research capabilities in one place.[200]

Fusionopolis Phase 2B

Largely a private sector-led project, Solaris was designed by Dr Ken Yeang, an architect famous for his green building designs, and developed by Soilbuild Group Holdings.[201,202] With approximately 50,000 m^2 of space, this project targeted tenants from the infocomm, media, science and engineering industries.[203] Like in Biopolis, tenants could use shared facilities, including an research and development (R&D) foundry for research into silicon, polymer, organics and magnetic devices, as well as testbeds for new technologies such as fuel cells and other alternative energy sources.

Phase 2B further adds to greenery within one-north with its provision of open, interactive public and semi-public spaces featuring the creative use of skylights in courtyards and cascading landscaped garden terraces.[204] As a testament to the attractiveness of Fusionopolis, French game developer Ubisoft set up a subsidiary in Solaris. The firm's Singapore team has since gone on to co-develop entries in the popular Assassin's Creed game.[205]

Fusionopolis Phase Three

Developed by Ascendas Real Estate Investment Trust, Nexus @one-north provided 25,500 m^2 of space targeted at tenants in the infocomm, media, physical sciences and engineering industries.

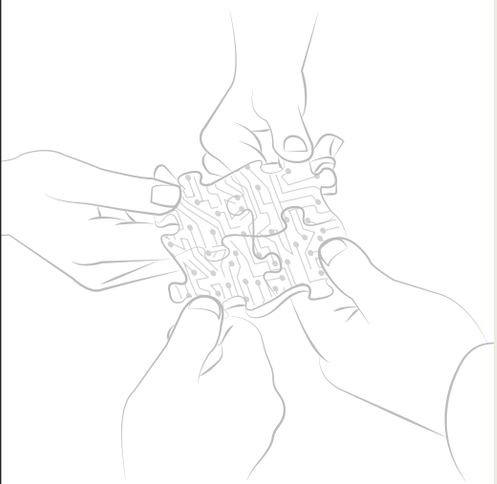
Fusionopolis Phase Four

The plot of phase four was allocated to Lucas Real Estate Singapore. The Sandcrawler building, named after the Star Wars transport vehicle, houses the regional headquarters of Lucasfilm Singapore, which has worked on Emmy Award-winning television series, Star Wars: The Clone Wars, and Rango, an Oscar-winning animated feature partially produced in Singapore.[206] The Walt Disney Company (Southeast Asia) and ESPN Asia Pacific are also located in the Sandcrawler.

Fusionopolis Phase Five

Galaxis, a 19,200 m^2 multi-tenanted facility developed by Ascendas and Mitsui, is a 17-storey building with a separate five-storey office block.[207,208] It provides 69,000 m^2 of ready-built space for business parks, retail, and work-office-home-office units—a new typology workspace supported by a small living component.[209]

GROWING THE HUB FOR PUBLIC-PRIVATE COLLABORATION



The strategic intent for Fusionopolis was for it to become a hub for public-private collaboration. Within Fusionopolis One, two A*STAR research institutes were installed to strengthen the cluster's attractiveness as a research hub and draw commercial research partners, as well as other ICT companies, with its research expertise and shared facilities.[210] The two A*STAR institutes were the Institute for Infocomm Research and the Institute of High Performance Computing (IHPC). They brought with them accompanying infrastructure and high-end equipment, which provided tenants of Fusionopolis access to cutting-edge computing and IT services.[211]

The A*STAR targeted a tenant mix that was thought to maximise benefits by capitalising on the resources and facilities of the institutes. The 13 companies that moved in when Fusionopolis One opened included manufacturers of communications equipment, software developers, and engineering companies. This paid off as public-private collaborations gained traction. For example, Lloyd's Register and IHPC opened a joint laboratory to leverage the institute's capabilities in computational fluid dynamics and engineering mechanics to deliver technological solutions for the marine, energy and offshore sectors.

This approach continued in Fusionopolis Two, where the Science and Engineering Research Council and the A*STAR's research institutes, which it oversees, are located. The research institutes have brought capabilities in diverse fields such as materials science and engineering, data storage, microelectronics, manufacturing technology, high-performance computing and info-communications research. With such a range of specialisations located in close proximity, Fusionopolis is able to offer varied capabilities to the private sector. In addition, the provision of shared infrastructure such as research equipment, core scientific services and conference facilities continue to support public-sector institutes and private-sector laboratories in one-north.

In order to ease the entry of ideas into the market, research institutes are not the only tenants at Fusionopolis. Also located there is Enterprise Singapore (ESG)—formed through the merger of International Enterprise (IE) Singapore and SPRING Singapore on 2 April 2018, which helps companies bring their ideas to market, or spark the interest of potential investors. The meshing of high-quality research and industrial links in one location adds to the attractiveness of Fusionopolis.[212] The unique public-private opportunities available in one-north will continue to be a major strength, facilitating the commercialisation of Singapore's research output.[213]

STRENGTHENING THE TALENT POOL

Investments channelled into creating spaces to nurture R&D have paid off. New jobs have been created and industries renewed. At the official opening of Fusionopolis Two in October 2015, Prime Minister Lee Hsien Loong noted that from 1990 to 2015, the number of research scientists and engineers working in Singapore had increased six-fold to 32,000. The number of start-ups also jumped from 24,000 in 2005 to 55,000 in 2015. This has, in part, been made possible by locating research institutes in close proximity, allowing Singapore to build and integrate capabilities in a broad range of subjects, including materials science, chemistry, and computational modelling. All of this has come together to support multi-national corporations (MNCs) and smaller enterprises.

Despite Singapore's successes, enterprises and institutions need to remain hungry and bold for Fusionopolis to grow from strength to strength. With the physical infrastructure largely in place, the onus is now on these parties to drive the spirit of research and entrepreneurship.[214]

LAUNCHPAD @ ONE-NORTH

> *Innovation is the only sustainable competitive advantage of the 21st century economy.*[215]
>
> S. Iswaran

Nurturing young companies was paramount for ensuring Singapore's competitiveness in the innovation race. In 2001, Phase Z.Ro was Singapore's first attempt to develop an ecosystem for start-ups. However, as the local start-up scene gained momentum, demand for space outstripped what Phase Z.Ro could offer.[216] To ensure that the innovation and entrepreneurship drive in Singapore would not rely solely on large research institutes, the Media Development Authority (MDA) and the JTC moved to set up LaunchPad @ one-north as a low-cost home for start-ups. The MDA and the Infocomm Development Authority (IDA) were restructured to form the Infocomm Media Development Authority (IMDA) in October 2016.

LaunchPad @ one-north.
Photo courtesy of JTC Corporation.

Prior to its launch, there had been various government efforts to nurture the growth of start-ups. With incentives such as tax benefits, a start-up friendly financial environment was created. Singapore's education system, including its institutes of higher learning, provided the intellectual capital. The main stumbling block was the lack of an entrepreneurial and collaborative culture as there were few places in Singapore where people could naturally come together to share ideas—a vital aspect for nurturing start-ups, as demonstrated by Silicon Valley's success in circulating ideas, money and know-how quickly. The LaunchPad @ one-north, which started life as "Block 71", would fill that gap by providing space for start-up founders, investors, incubators and other building blocks of the ecosystem to come together to form a network.[217]

Ayer Rajah Industrial Estate.
Photo courtesy of JTC Corporation.

Flatted factories in Ayer Rajah Industrial Estate built in the 1970s for light manufacturing industries (left) were repurposed as spaces for startups (right).
Photo courtesy of Abhishek Kumar, flickr.com/photos/Abhishek_kr7/3227742428 (left) JTC Corporation (right).

Block 71 of Ayer Rajah Industrial Estate in one-north was a drab and utilitarian flatted factory block built in the 1970s. When its tenants vacated the space in 2010, the then MDA seized the opportunity to strike a deal with the JTC to lease five floors of Block 71 for media start-ups supported by the government agency. NUS Enterprise, which promotes entrepreneurship and innovation at the university, and Singtel Innov8, a corporate venture capital fund, were brought in as partners to help attract start-ups.

Block 71 was refurbished to make its interior more appealing to the bright young minds that would work there. Besides infrastructure refurbishments, changes included co-working spaces, conference rooms, meeting facilities and a community space called Plug-in @ Blk 71 to serve as the nucleus of the incoming start-up community.[218] The block reopened in April 2011 as "Mediapolis Phase Zero", but it remained better known as Block 71.[219] However, despite attractive rental subsidies from the erstwhile MDA to bring in media startups and companies, it remained largely vacant because of poor transportation links. It was only after the one-north MRT station opened in October 2011 that tenants started streaming in.

Organisations such as NUS Enterprise helped build connections among start-ups, linking them to funding resources, organising workshops and providing basic infrastructure. Based in Block 71, NUS Enterprise's work complements its NUS Overseas Colleges (NOC) programme that offers select top students opportunities to work at prominent overseas start-ups for a year. In fact, founders of many successful start-ups in Singapore were graduates of the NOC programme.[220]

Block 71 provided start-ups space to come together as a community to expand social connections and access resources through the sharing of technical expertise. With a thriving community, other start-ups began gravitating to the area. Hosting a motley crew of start-ups, venture capitalists and incubators, tenants of Block 71 hoped to either be the next big thing, or invest in the next big thing.[221]

A networking session organised by NUS Enterprise in Block 71.
Photo courtesy of NUS Enterprise.

This little experiment would go on to do so well that, in 2014, the concept was expanded to neighbouring Blocks 73 and 79 to provide more institutional support and infrastructure to aid the growth of start-ups.[222] The enclave, renamed LaunchPad @ one-north, officially opened on 23 January 2015.[223,224] It was conceptualised as a hub to bring together members of the local start-up community, including early-stage local and foreign technologists and investors.[225,226] Its strategic location in one-north offered start-ups access to a range of businesses and multi-disciplinary R&D programmes, as well as the talent pool and resources of neighbouring institutes of higher learning such as the NUS, Singapore Polytechnic, and the INSEAD Asia Campus and ESSEC business schools.[227]

INSEAD Asia Campus (left) and ESSEC Business School (right) located within one-north.
Photo courtesy of JTC Corporation.

More amenities were added subsequently, including a food court, a basketball court, a futsal court, event spaces and shared meeting rooms.[228] Blocks 75, 77 and 81 were added to the enclave in 2016, providing an additional 12,000 m^2 of plug-and-play space to support the start-up ecosystem.[229] Timbre+, a 23,000 m^2 650-seat food hall, was created to serve the working population by rebuilding an old food centre.[230] Opened in 2016, the "gastropark" housed food stalls operating out of repurposed shipping containers and caravans. Timbre+ quickly became a place for the start-up community to unwind and network after office hours.[231]

Timbre+—650-seat food hall catering to the working population in one-north.
Photo courtesy of JTC Corporation.

While proximity helps facilitate the exchange of ideas, other mechanisms are also necessary to actively promote interaction. These include the attraction and retention of human capital, workplace culture and quality of life.[232] Events such as networking sessions, hackathons and technology interest group meetups help to build up the start-up community and develop a sense of solidarity among tenants of LaunchPad. This also helps build a critical mass that would eventually become self-reinforcing, with established start-ups providing advice and contacts to newer ones.[233] Collaborations could also spill over to the larger one-north community. For example, Neeuro, a start-up at LaunchPad took advantage of its location to work closely with the A*STAR to develop a headband that allows consumers to play games on a tablet using their brainwaves.[234]

Alongside start-ups that directly leased space from the JTC, there are approximately 50 incubator spaces operated by venture capitalists and private companies. TRIVE, TNB Ventures, Red Dot Drone, and PSLove are some of the incubator tenants of LaunchPad. Some of the start-ups are led by individuals who used to work at other start-ups housed within LaunchPad. Many prefer to remain at LaunchPad as they have built up connections with stakeholders and other start-ups in the community.

From its relatively innocuous start, LaunchPad @ one-north has grown to become a focal point of Singapore's start-up scene. It houses an increasingly diverse range of enterprises from different fields such as engineering, infocomm, media, biomedical, financial technology (fintech) and urban solutions. There is also growing interest from international incubators and corporations that see value in being plugged into the LaunchPad's start-up community in order to tap into new technologies being developed for regional and global commercialisation.[235]

CHAPTER 5

MEDIAPOLIS: PROMOTING INTERACTIVE DIGITAL MEDIA INDUSTRY

MEDIA 21 PLAN: MAKING SINGAPORE A GLOBAL MEDIA CITY

The idea of Mediapolis was mooted in September 2002 by a panel on creative industries under the government's Economic Review Committee (ERC), which had been set up towards the end of the previous year to formulate strategies for Singapore's comprehensive economic restructuring following a global downturn. It was envisioned as a cluster of media production and research and development (R&D) activities in a work, live, play and learn environment to create high value-added products and support experimentation and multi-disciplinary collaborations.[236]

The ERC panel also outlined the Media 21 plan, which was launched in 2003 and envisioned an ecosystem to make Singapore a vibrant global media city to help foster a creative economy and a connected society. The plan sought to double the media cluster's contribution to Singapore's economy to 3% by 2012, creating 10,000 new jobs for Singaporeans.[237] The Media Development Authority (MDA), formed in 2003, would work closely with agencies including the Infocomm Development Authority (IDA) and International Enterprise Singapore to drive the development of the industry. The MDA and IDA were restructured to form the Infocomm Media Development Authority (IMDA) in October 2016.

By the mid-2000s, the information and communications technology (ICT) sector was transforming the way people interacted with digital media content. With the industry constantly buffeted by technological disruptions, locating Mediapolis in one-north would help industry players better understand and cope with the impact of such disruptions by interacting with others in related sectors such as ICT.

Planned as a 190,000 m^2 complex, Mediapolis would include state-of-the-art facilities as well as serviced apartments and hotels.[238] Being a creative hub, it was in keeping with one-north's mission and was expected to help further develop the innovation district's lifestyle element.[239] While the JTC was responsible for the development of the basic infrastructure for Mediapolis—such as the fibre-optic network, chilled water and electricity needs—the one-north Development Group also had to understand the requirements of the media industry.

The development of Mediapolis began in early 2009, and thus far it has three completed developments—the Mediacorp Campus, Infinite Studios and ALICE @ Mediapolis.

PLANNING OF MEDIAPOLIS

Mediapolis would bring the digital media industry into the high-tech cluster. State-of-the-art facilities such as soundstages and film production resources to be housed there were expected to give Singapore a leg up in attracting global media companies.

Building a successful media cluster required three key ingredients: industry knowledge, planning and development knowledge, and technical knowledge. Trends in the global media industry needed to be studied to better understand market cycles and identify sunrise segments in order to decide how best to position Mediapolis on the global stage. For Mediapolis to be sustainable, knowledge of the business models of different industry segments was crucial for targeting the right kind of companies. Understanding linkages between different industry segments would be essential for planning how to cluster media companies. Such knowledge would allow the JTC to design the physical infrastructure, including details such as the types of sectors that should be located close to one another to help nurture the 'software', or networks, within the business community. Furthermore, the work patterns and norms of the industry would affect how Mediapolis would be laid out.

Development models of essential media infrastructure and facilities also needed to be identified. Understanding the technical requirements would allow the JTC to better gauge the construction costs of these vital elements that would eventually serve as the gauge of Mediapolis' commercial success.

Some facilities, which benefit from economies of scale, were not expected to be commercially viable on their own. For example, the construction of a soundstage alone—an aircraft hangar-like structure used for film and television production—would not have turned a profit. A soundstage allows production houses to control lighting, temperature and other variables during production. The studios must also house other facilities, such as equipment stores, green rooms, loading and unloading bays that are essential for the efficient operation of the soundstage. Business support services, production companies, food and beverage (F&B) and retail options, as well as media schools are co-located with the building to provide support services to companies that use the soundstage.

Mediapolis would once again be a whole-of-government effort. While the JTC focused on the master planning of the site, the development of different clusters within Mediapolis and the construction of crucial media infrastructure, the IMDA would bring in local media companies and focus on talent and capability development in Singapore. The Economic Development Board (EDB), on the other hand, would focus on the marketing and positioning of Mediapolis overseas, along with anchoring foreign investment and international media companies in Singapore.

CO-LOCATION OF LOCAL AND INTERNATIONAL MEDIA COMPANIES

Mediapolis' growth has been in keeping with regional trends in Asia, where an increasingly affluent middle class has fuelled demand for digital media content. To tap this growing market, major entertainment and animation firms have set up subsidiaries in Singapore.[240] Visual effects studio Double Negative, along with traditional media outlets such as Disney, Viacom and Pearson are among companies that have based some of their operations in the city-state.

However, the biggest tenant to move to Mediapolis was Singapore's national broadcaster, Mediacorp (See Box Story: Relocation of Mediacorp Campus on p. 74). As the country's largest media broadcaster and entertainment company, Mediacorp acts as the media industry anchor in one-north.[241] The co-location of local and foreign media businesses, with Mediacorp as the centrepiece, was expected to pave the way for firms to participate in collaborative projects.

The benefits of co-location also attracted Infinite Studios, an integrated media entertainment and creative services company, to base its production arm at Mediapolis. Infinite Studios supports media productions with its state-of-the-art infrastructure, including two of the largest soundstages in Singapore in a 24,078 m^2 development that bears its name.[242] The development is a joint venture between Ascendas—which merged with Singbridge to form Ascendas-Singbridge in June 2015—and Citramas Nusaterra.[243] As the first development in Mediapolis in 2014, Infinite Studios offers a unique platform for companies to complement each other to serve the global media industry.[244] The other anchor tenant at the development, satellite transmission specialist Globecast, offers satellite uplink and downlink facilities. Infinite Studios is also home to Discovery Networks and Japanese game developer Bandai Namco.[245]

FIRST OCCUPANT: INFINITE STUDIOS

> *I wrote an initial white paper about a film studio that had an ecosystem around it. It had office space for creative, like-minded companies who needed to share a single facility. It was a multipurpose facility that had all the trappings of what the creative community needed, including F&B, retail...sort of like a 24-hour living centre, because...our lifestyle as a post-production house was [that of] living round the clock.*[246]
>
> Mike Wiluan

Scaling up from a post-production studio catering to a client base from advertising and film-making industries, Infinite Studios (previously known as Infinite Frameworks) was formerly housed in three shophouses located in the trendy neighbourhood of Bukit Pasoh for more than 10 years. The need to move to a larger space arose once the business expanded to become a production house.

Mike Wiluan, Chief Executive Officer (CEO) of Infinite Studios, recounted that notable industry players from Europe and the United States saw Singapore as an interesting and vibrant city that could serve as a very filmable backdrop. However, besides Mediacorp-owned studios formerly located at Caldecott, there was a lack of available indoor studios and soundstage facilities. He saw an opportunity for creating an ecosystem centred around a film studio to provide jobs and create communities, similar to established media ecosystems in Gold Coast, Australia, and Burbank, California.

Wiluan was invited by the JTC and the former MDA to discuss the Media 21 blueprint featuring the idea of Mediapolis. He was shown a potential plot of land where the soundstage black box could be located, and was informed that surrounding media-centric properties would feed into the life and workflow of the ecosystem. While the blueprint was impressive, forward-looking and aggressive in demonstrating enthusiasm for media facilities set in a lively environment bustling with activities, its success could only be achieved with planning, policy alignment and coordination among stakeholder agencies as well as continuity in legacy decisions made under the Media 21 blueprint. Wiluan cited high land rent and stringent regulations such as adherence to media-centric occupancy imposed by the JTC as key challenges faced by the fledgling film industry in Singapore, which had few private players with limited capital to invest in extensive infrastructure. He proposed that a mixed-use development, instead of just media and information technology businesses, could be allowed in Mediapolis.

Infinite Studios at Mediapolis.
Image courtesy of JTC Corporation.

Instead of purchasing the land for development, Wiluan and his partners in the joint venture between Ascendas and Citramas Nusaterra opted for a land-rental scheme under which the soundstage complex known as Infinite Studios was designed and built with the JTC's approval. It took two-and-a-half years to build and was officially opened on 17 January 2014. In addition to the two soundstages of 1,672 m^2 and 929 m^2 respectively, it offers 1,393 m^2 of supporting production office, dressing and equipment rooms.[247]

Infinite Studios went on to build two larger soundstages on the Indonesian island of Batam, just 40 minutes by ferry from Singapore. The Batam studio houses 1,300 m^2 and 2,787 m^2 soundstages and a 10,000 m^2 back lot facility suited for creating period settings. It seeks to complement Singapore's technology-oriented productions "by providing larger scale productions with sets and props and a natural island resort environment as locations for filming", according to Infinite Studios' website.[248]

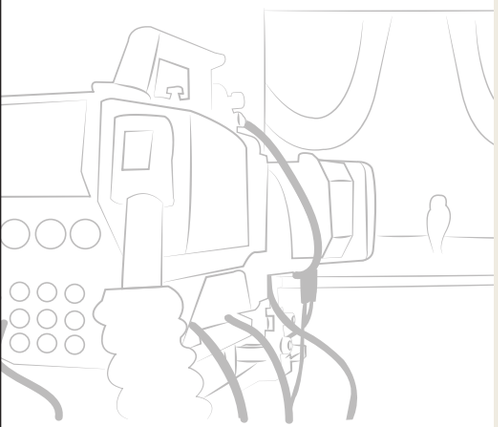
Being the most recent development in one-north, Mediapolis will continue to be shaped by future additions to the innovation district. In 2016, a unit of Boustead Projects Ltd. clinched a contract from the JTC to develop a multi-tenanted development in Mediapolis. Developed with a 30-year lease term, the 12-floor business park named ALICE @ Mediapolis, is the cluster's third development.[249]

RELOCATION OF MEDIACORP CAMPUS

Mediacorp people [need] to more deeply interact with the technology people, the business people...so that they can better understand the technological trends and disruptive forces.[250]

Teo Ming Kian

The relocation of Mediacorp from its former Caldecott campus to Mediapolis in one-north was to facilitate interaction with other technology and business sectors. Such interaction could create a better understanding of the technological trends and disruptive forces that could potentially affect the media industry, allowing players to better prepare for them.[251] The relocation of Mediacorp was also thought to be important in encouraging the media industry to be anchored in one-north.[252] At the same time, the Caldecott Broadcast Centre, which had been home to Mediacorp for nearly 80 years,[253] was showing its age and falling into a state of disrepair. Teo Ming Kian, who served as Mediacorp chairman from 2010-16, recalled that he would go to bed at night fearing that television screens would go blank "because you don't know what is going to fall apart".



Mediacorp Campus at Mediapolis.
Photo courtesy of JTC Corporation.

Although a site located near Bukit Gombak was purchased for Mediacorp's relocation, it was a typical fenced-up film studio site in a remote area and not well-suited to allow the kind of cross-sectoral interaction the media industry needed. Hence, when the JTC approached Teo with the opportunity to locate the new Mediacorp Campus in one-north, he instructed the architect, Maki & Associates, that apart from the important areas that needed to be secured, the new campus should be free of barriers or fences to allow people to move around easily to interact and help create vibrancy.[254]

Home to local celebrities, the Mediacorp Campus at Mediapolis is an 80,000 m^2 development comprising three buildings—a 1,600-seat theatre, the Broadcast Centre housing three large production studios and Mediacorp's corporate office. The three buildings create a 'view corridor' that acts as both a pedestrian spine as well as a public plaza with a grand stairway. Visitors can enjoy panoramic views from a viewing plateau at the top of the stairway linking to the one-north Park and amenities such as eateries.[255] The campus was honoured at the prestigious President's Design Award in 2018.[256]

As Prime Minister Lee Hsien Loong noted at the official opening of Mediacorp Campus in 2015, in the face of globalisation of creative content from streaming services and social media, it is imperative that Singapore continues to produce content that reflects the country's culture, heritage and society.

CHAPTER 6

CONCLUSION

MOVING FORWARD: STRENGTHENING THE ECOSYSTEM FOR RESEARCH, INNOVATION AND ENTREPRENEURSHIP

> *Perhaps the biggest lesson [from one-north was] that…the force of institutions, conventional wisdom [is] very, very difficult to overcome. But you have to persevere and keep at it. Breaking out of the box doesn't come easy.*[257]
>
> Goh Kok Huat

Currently one-north houses 400 leading companies and global institutions, six institutes of higher learning and corporate universities, 16 world-class public research institutes and 50 incubators with approximately 800 start-ups. Together, they have a working population of about 50,000.[258]

The district has provided an ecosystem for scientists, engineers and researchers to congregate and transform their studies into innovations for real world application. Supported by a sound regulatory framework, Singapore is slowly becoming a place that brings together creators of intellectual property and risk-taking entrepreneurs who understand the technology, trends and markets. This potent mix has enabled ideas to come to fruition, furthering the development of Singapore's knowledge-intensive economy.[259]

The JTC's success as a master developer in the early phases of planning and developing industrial estates allowed the agency to experiment with planning guidelines in one-north. The biggest testament to one-north's success is the fact that many ideas tested there have been taken as reference in several subsequent projects, including the upcoming Punggol Digital District in Singapore. The benefits of continuous prototyping of concepts at one-north have been externalised to districts throughout the city-state, adding to its know-how in urban planning and management.[260] NUS Enterprise has also successfully supported the establishment of incubation facilities abroad, such as the start-up hubs in San Francisco and Jakarta called BLOCK71.[261,262] one-north continues to serve as an experimental site for testing new ideas. It is a pilot zone for autonomous vehicle trials since 2016 and has been designated as Singapore's first drone estate in 2018, offering an urban environment for testing unmanned aircraft systems.[263,264]

However, as successive teams take on the role of developing and managing one-north, the government's original mission of building a vibrant place that acts as the vanguard of Singapore's knowledge economy risks becoming diluted. These teams should remember not to treat one-north as just another typical business park.[265]

Within one-north, plans for its future development continue to evolve. Industries key to the future of Singapore's economy will be identified and seeded in the district.[266] Land has been set aside in the original master plan for yet-to-be-confirmed hubs.[267] Notably, Ascendas Vista Property Pte Ltd, a subsidiary of Ascendas-Singbridge, won a tender in February 2018 to develop a Mixed-use Executive Centre (MEC). When completed, it would be Singapore's first shared executive learning centre dedicated to the development of talent and leadership.[268] The injection of a bigger live-in population by way of providing affordable housing options could be further explored.

Within the greater one-north area, further integrating one-north with the National University of Singapore (NUS) would be mutually beneficial at a time when the university is looking to improve its linkages with industry and expand its role beyond teaching and research. Closer integration with education and research institutions in the area could create new opportunities to testbed.[269] The 24-km Rail Corridor running through one-north, which once housed a railway track, could also potentially be integrated with the precinct and be used for activities such as outdoor film screenings.[270] The re-purposing of the railway track would also help link one-north with the neighbouring Tanglin Halt Estate.

It may be too early to assess one-north's success in achieving its original vision of creating a vibrant work, live, play and learn environment. After all, Silicon Valley took half a century to develop the vibrancy it has come to be known for. Ultimately, one-north's success will depend on the people developing it. Future teams overseeing the district will need the grit to overcome institutional habits and conventional wisdom to champion its transformation through a constantly evolving process that allows new developments to germinate spontaneously.

POST-SCRIPT

The conception of one-north marked a new chapter in Singapore's economic and industrial development. Its idea was rooted in the notion that innovation does not occur in isolation, and that local environment plays a vital role as an incubator. The development of the 200-hectare (2 km^2) research hub in one-north would become the beacon of Singapore's innovation ecosystem. To support the growth of biomedical sciences, information and communication technology, media, physical sciences and engineering industries, one-north was developed based on an integrated master planning approach to combine the elements of work, live, play and learn. As a result, it is visibly different from other business and science parks in Singapore. Zaha Hadid's master plan envisaged a groundbreaking spatial environment—one that challenged existing norms and pushed the envelope in its search of a new spatial experience. one-north was not only carefully designed to encourage serendipitous interactions among the research community, but also incorporated residential elements to facilitate community bonding.

To add vibrancy after working hours, the JTC has introduced placemaking strategies such as the annual one-north Festival focused on science and technology, co-organised with Agency for Science, Technology and Research (A*STAR), and the Car-Free Sunday initiative jointly organised with the Urban Redevelopment Authority. The JTC has also opened up spaces in one-north for interest groups to hold their events and activities. For instance, The Cycling Chap, a group of bike enthusiasts, held their mountain bike street cycling challenge and Strider challenge for toddlers at Biopolis. Such carefully designed programming enables different community groups to interact and bond.

LaunchPad @ one-north offers a conducive environment and ecosystem to more than 800 start-ups to cultivate a burgeoning community of entrepreneurs. Other exciting plans in store for one-north include it being designated as Singapore's first drone estate to provide companies and research institutes an urban environment to testbed innovative unmanned aircraft systems.

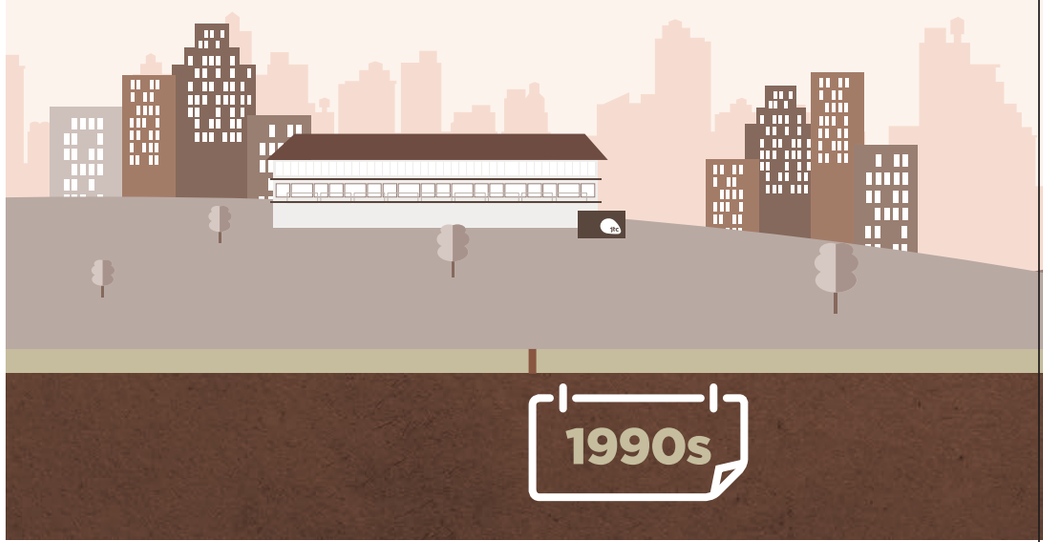
However, physical infrastructure is only a part of the recipe for a successful innovation district. To continue supporting the spirit of experimentation, there is a need to constantly nurture the right talent and attract the right mix of entrepreneurs and enterprises. With its critical mass of talent, conducive environment for research, innovation and entrepreneurship, one-north's innovative milieu stands out as a collaborative industry ecosystem, as well as an attractive workplace and vibrant community space.

Ng Lang
Chief Executive Officer
JTC Corporation

MILESTONES OF ONE-NORTH

1998
- Plan for a $5 billion Science Hub in the Buona Vista area announced at TechVenture 98.

1999
- Buona Vista Science Hub (later renamed one-north) announced as a key thrust of the Technopreneurship 21 initiative.



1990s

2000
- The JTC appointed lead agency for developing the Buona Vista Science Hub.

2001
- Phase Z.Ro Technopreneur Park developed as a pilot.
- one-north officially launched by then Deputy Prime Minister Tony Tan.
- Zaha Hadid Architects appointed as master plan consultant.
- Groundbreaking ceremony of Biopolis.

2002
- The JTC appointed master tenant of Chip Bee Gardens by The Singapore Land Authority (SLA).

2003
- Biopolis Phase One opened.

2004
- The JTC assumed ownership of Wessex.

2005
- one-north Park at Biopolis completed.

2007
- Official launch of PIXEL.

2008
- Fusionopolis Phase One (Connexis and Symbiosis) completed.
- Wessex Village Square launched.

2009
- Development of Mediapolis started.

2000s

2010
- Fusionopolis Phase 2B (Solaris) completed.
- Biopolis Phase 3 (Synapse and Amnios) completed.

2011
- Development of Mediapolis Phase Zero (later renamed LaunchPad @ one-north) and Fusionopolis 2A started.
- The Star Vista and The Rochester opened.
- one-north Mass Rapid Transit (MRT) station on the Circle Line opened.

2013
- Fusionopolis Phase 3 (Nexus) completed.
- Biopolis Phase 4 and 5 (Procter & Gamble Singapore Innovation Centre and Nucleos) completed.

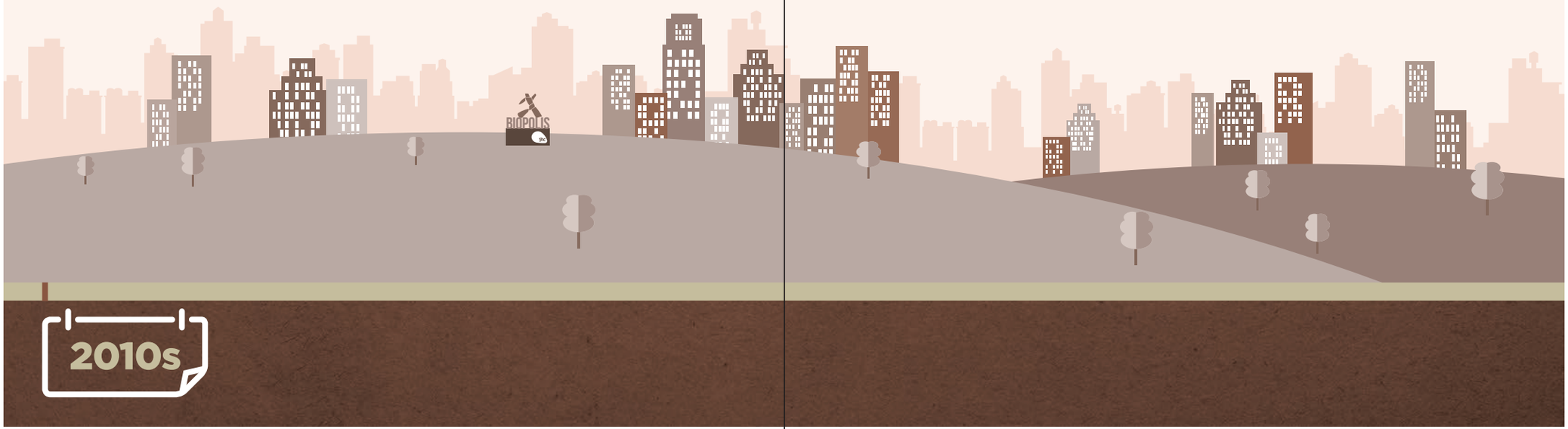
2014
- Official opening of LaunchPad @ one-north.
- Fusionopolis Phase 4 (Sandcrawler) completed.
- The Metropolis opened.
- Fusionopolis Phase 5 (Galaxis) completed.
- Infinite Studios at Mediapolis opened.

2015
- Fusionopolis Phase 2A (Innovis, Kinesis, and Synthesis) completed.
- one-north Park at Mediapolis opened.
- Mediacorp moved into Mediapolis as anchor tenant.
- Autonomous vehicle trials permitted in one-north.

2016
- one-north Park at Rochester West, Rochester East, Fusionopolis North and Fusionopolis South opened.

2017
- one-north announced as first business park in Singapore to implement an open platform where Personal Mobility Devices (PMD) sharing service operators are able to testbed their operating models.

2018
- one-north designated as the first drone estate in Singapore.
- Ascendas-Singbridge won the JTC tender for development of Mixed-use Executive Centre, Singapore's first dedicated shared executive learning centre.
- First Car-Free Sunday Singapore organised outside Civic District was held at one-north.



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APPENDIX A

Implementation Framework for one-north

E-21 Ministerial Committee

Comprising individuals from the highest levels of government, the E-21 Ministerial committee worked to ensure that the development of one-north adhered to Singapore's macro goals and its broader national strategy. Chaired by then Deputy Prime Minister Tony Tan, it included heads of the Ministry of Trade and Industry (MTI), the Ministry of National Development (MND) and the Land Transport Authority (LTA).

one-north Steering Committee

Comprising key personnel from government agencies and ministries involved in the development of one-north, the committee focused on resolving policy-related issues and inter-agency conflicts. It was headed by a minister and its members included the chairmen of the Economic Development Board (EDB) and erstwhile SPRING Singapore, as well as the CEOs of the Urban Redevelopment Authority (URA) and the LTA. Then Minister for the Environment, Lim Swee Say, was appointed Chairman, with then Senior Minister of State for Trade & Industry and Education Tharman Shanmugaratnam as Deputy Chairman.[271]

one-north Review Committee

Chaired by then CEO of JTC, the committee looked at resolving technical-related issues spanning multiple agencies. It provided the one-north Development Group a direct line to the CEO and Chairman of the JTC, cutting through bureaucratic layers in the process.

one-north Software Remaking Committee

The committee focused on promoting the testing of new ideas or approaches in one-north among different agencies. It was responsible for ensuring that one-north could act as a sandbox for test-bedding new ideas to see if they could be exported to the rest of Singapore. The committee was chaired by the Permanent Secretary of the MTI.

one-north Resource Advisory Panel

The panel acted as an international advisory board. Active from 2001-05, it was not officially disbanded and comprised top city planners and architects from the private sector who could provide an international perspective and lend their varied experience to determine one-north's strategic direction, and help address operational issues. It recommended ideas, though the decision to implement them remained with the one-north Development Group. The panel was chaired by the Permanent Secretary in the Ministry of Information and the Arts and included renowned experts such as Liu Thai Ker, Rosabeth Kanter, Alfonso Vegara, W. Chan Kim and Renee Mauborgne.

Master Plan Selection Committee

The committee was tasked with the selection of the master plan for one-north.[272] It was chaired by Lim Neo Chian, former Deputy Director of the EDB, and included members such as the Chief Planner of the URA, CEO of the LTA, President of the Singapore Institute of Planners (SIP), President of the Singapore Institute of Architects (SIA) and Kisho Kurokawa, a leading Japanese architect.

APPENDIX B

Developments in one-north

Nepal Hill

The Nepal Hill area was conceived as a global leadership and talent-development hub. It includes 12 conserved black-and-white colonial bungalows, of which eight provide on-site accommodation and one was redeveloped into a cafeteria.[273] Nepal Hill also houses Unilever Four Acres Singapore, a 9,000 m^2 training centre and global hub for the company's leadership development programme, alongside the ESSEC Business School, a 6,500 m^2 executive campus.

one-north Park

Spread across 160,000 m^2 of land separated by roads, one-north Park consists of 13 green spaces.[274] Following the natural topography of the land, one-north Park weaves through the district and is a key element of its master plan to create a work, live, play and learn environment. The park is not only a green area for recreation, it is also intended to act as a connector between the various clusters in one-north. Its design embraces the area's existing unique strengths, such as an undulating terrain, lush and diverse greenery, heritage elements and tropical weather. Walking through the linear park, gives visitors a unique perspective of one-north.[275] However, this has also resulted in a mildly strenuous walk, with the hilltop at a level of 37 m.[276] To address the challenges of an undulating terrain, the construction of a bridge from Star Vista to one-north Park was proposed in Zaha Hadid's master plan.[277] By connecting the two areas, the flow of energy and movement of people could be maintained.[278] However, the bridge has not been constructed so far.

one-north Residences

A 40,000 m^2 luxury condominium with a club house and sky gym right in the heart of Fusionopolis, one-north Residences breaks the mould of conventional condominiums in Singapore by allowing public access to its plaza and retail outlets. A mix of low gating and transparent barriers add to the sense of porousness within one-north Residences. Residents still enjoy security features, such as secure card access to the lift lobbies of apartment blocks, swimming pools and gym.[279]

Rochester Park

The colonial-era military barracks at Rochester Park have been granted conservation status to preserve the history of the site. These low-rise buildings act as a counterbalance to the high-rise and high-density developments in one-north, providing a contrasting spatial pattern and a historical counterpoint to the futuristic developments in the district.

Rochester Park was first developed by the JTC as a lifestyle hub. Eleven bungalows were dedicated to food and beverage (F&B), retail and healthcare services, near the Rochester Mall and Park Avenue Rochester hotel. This turned Rochester Park into a unique social node for the one-north community. Rochester Park will be further developed into a vibrant talent development node alongside Nepal Hill. Besides chemicals giant BASF's Learning Campus and GSK Asia House, Ascendas-Singbridge is also contributing to the creation of this ecosystem by building a mixed-use development with a shared executive learning centre, commercial office, restaurants and a hotel embedded in Rochester Park's lush greenery.

The Metropolis

The Metropolis was conceptualised to be the gateway to one-north.[280] It contains more than 110,000 m^2 of prime office space in two signature towers that house the regional headquarters of multi-national corporations and local corporate giants—including Procter & Gamble and Royal Dutch Shell—close to their research facilities in one-north. Each tower provides large floor plates of up to 2,694 m^2. Completed in 2013, The Metropolis has been awarded the BCA Green Mark Platinum.

The Star Vista

The Star Vista is a civic, cultural and retail complex boasting 62,000 m^2 of retail space, a 5,000-seat performing arts theatre and a cavernous Grand Foyer. The Star Vista is the nation's first naturally cooled mall. Its unusual layout and impressive architecture offers ample shade and air movement, while a huge water feature enhances the building's balmy atmosphere.[281]

Since its opening in 2011, The Star Vista has drawn more people to the area. Designed by American architect Andrew Bromberg of Aedas, the $976 million mall boasts 110 food and retail outlets.[282] The performing arts theatre and auditorium, the largest of its kind in the suburbs, is used by megachurch New Creation for its services, ensuring a steady flow of people on weekends.[283] By designing the compound as an integrated unit, The Star Vista optimises the relationship between the retail and cultural components.[284] Together with the next door Rochester Mall, one-north's retail and lifestyle cluster has attracted not only people working and living in the area, but also those from nearby districts.

Wessex

One of the heritage areas identified in one-north, Wessex adds to its work, live, play and learn aspects.[285] Located in the Portsdown area, Wessex's affordable loft spaces have appealed to creative persons since the 1990s. This imparts vibrancy and a unique bohemian vibe and has attracted an interesting mix of residents—from engineers and doctors to students and artists.

Wessex Residences comprise 58 colonial black-and-white semi-detached houses and 26 blocks of walk-up apartments, set amid verdant surroundings of the low hills off Portsdown Road. The government's efforts to turn Portsdown into a hub for artists has resulted in institutions such as the Centre Stage School of the Arts, art galleries and photography studios being added to the mix.[286]

The 'play' aspect can be found in Wessex Village Square. Contained in 930 m^2 of refurbished space, it caters to the discerning lifestyle and dining needs of the sprawling residential precinct. Addressing the 'learn' aspect is the Tanglin Trust School, which provides a British-based education to the international community in Singapore. The 'work' component can also be found in four blocks of walk-up apartments that have been refurbished into 24 experimental work lofts to nurture smaller companies in the media and creative arts.

The park serves as a social space to promote greater interaction and networking within the one-north community, facilitating the cross-fertilisation of ideas and spur innovations. As of 2018, more than half of one-north Park had been completed. Future additions will be made on a just-in-time basis, with new sections being completed in tandem with the surrounding developments.[287]

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