

**Industrial Infrastructure: Growing in Tandem with the Economy** – Industrialisation has driven the engine of Singapore’s remarkable economic transformation since it gained internal self-government. This economic growth has developed in tandem with the industrial infrastructure landscape – its foundations were laid first in standard factories, and as the economy moved up the value chain towards a knowledge-driven phase, with ever more specialised industrial parks and innovative solutions. Singapore has had to deal with the constant challenge of staying relevant and competitive, while addressing the inherent constraints of land and labour. It is a story of visionary leadership, strong institutions, planning over a long-term horizon but adjusting flexibly in the short term, using crises as opportunities for learning and change, working with markets, and constant innovation. This study presents the progression of Singapore’s economic policies over the various phases of growth, and the corresponding developments in the industrial infrastructure. It also delves into how this integrated approach has occurred through the dynamics of the institutional structures and Singapore’s strategic industry choices over the years.

The **Singapore Urban Systems Studies Booklet Series** draws on original Urban Systems Studies research by the Centre for Liveable Cities, Singapore (CLC) into Singapore’s development over the last half-century. The series is organised around domains such as water, transport, housing, planning, industry and the environment. Developed in close collaboration with relevant government agencies and drawing on exclusive interviews with pioneer leaders, these practitioner-centric booklets present a succinct overview and key principles of Singapore’s development model. Important events, policies, institutions, and laws are also summarised in concise annexes. The booklets are used as course material in CLC’s Leaders in Urban Governance Programme.

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# Industrial Infrastructure

*Growing in Tandem with the Economy*



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GROWING IN TANDEM WITH THE ECONOMY

Centre for Liveable Cities

Ministry of National Development, Singapore

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JTC Corporation

Ministry of Trade and Industry, Singapore



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The Singapore Economic Development Board (EDB) is the lead government agency for planning and executing strategies to enhance Singapore's position as a global business centre. EDB dreams, designs and delivers solutions that create value for investors and companies in Singapore. Our mission is to create for Singapore, sustainable economic growth with vibrant business and good job opportunities.

EDB's 'Host to Home' strategy articulates how we are positioning Singapore for the future. It is about extending Singapore's value proposition to businesses not just to help them improve their bottom line, but also to help them grow their top line through establishing and deepening strategic activities in Singapore to drive their business, innovation and talent objectives in Asia and globally.

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# JTC Corporation

JTC Corporation (JTC) is Singapore's leading industrial infrastructure specialist spearheading the planning, promotion and development of a dynamic industrial landscape. JTC has played a key role in the growth of Singapore's economy by pioneering cutting-edge industrial real estate solutions. Some of its landmark projects include CleanTech Park, a chemicals hub on Jurong Island, Jurong Rock Caverns, Seletar Aerospace Park, and Tukang Innovation Park.

Other key projects include wafer fabrication parks, business parks, Biopolis, Fusionopolis and Mediapolis at one-north, biomedical parks as well as logistics hubs for various industries. These industrial and business parks are now home to renowned global companies and promising local enterprises.

As Singapore transforms itself for the future, JTC, as the industrial infrastructure innovator, will partner with its customers to understand their evolving needs and develop appropriate 'future-ready' infrastructure solutions. JTC will continue to break new ground and expand its innovation capacity to offer infrastructure facilities of a calibre that sets the city state apart as an investment location.

For more information on JTC and its products and services, please visit [www.jtc.gov.sg](http://www.jtc.gov.sg).



# Foreword

Over the past few decades, Singapore has remarkably transformed itself from a colonial entrepôt economy to a thriving industrial economy. Upon achieving self-government in 1959, Singapore was faced with serious problems of massive unemployment and domestic chaos. Its astute leadership took the decision in 1961 to set up the Economic Development Board (EDB) to promote and attract multinational corporations investments to Singapore to create urgent employment opportunities. The Jurong Industrial Estate was created out of the island's western swampland to provide the necessary infrastructure for industrialisation. On achieving full independence in 1965, the young Republic of Singapore established the Jurong Town Corporation (JTC) in 1968 to develop several industrial estates across the island and accelerate the pace of industrialisation.

Despite various setbacks along the way, Singapore has seen rapid economic growth since then. This has developed in tandem with the industrial infrastructure landscape — its foundations were laid first in standard factories, and as the economy moved up the value chain, with ever more specialised industrial parks and innovative solutions.

Today Singapore pursues the goal of a knowledge-oriented economy. It is supported by strong investments in technical and tertiary education, cutting-edge industrial infrastructure like the chemicals cluster on the massively reclaimed Jurong Island, and investments in the biomedical sciences research cluster at Biopolis and the science and engineering research cluster at Fusionopolis, both located at one-north on the outskirts of the vibrant Singapore city centre.

*Industrial Infrastructure: Growing in Tandem with the Economy* opens by drawing the context in which Singapore shaped its global export-led industrialisation approach. It then traces the evolution of Singapore's economic priorities from the early days till today, and the corresponding developments in industrial infrastructure. It takes readers through the challenges faced at each phase of growth and how the key policies and decisions were crafted and implemented. Finally, it delves into the dynamics of Singapore's industry choices over the years and the strong institutional structures — characterised by the EDB-JTC relationship — that has enabled its successful industrialisation experience.

I hope that this Urban System Study will lend you a deeper insight into the dynamic iterations behind Singapore's economic and industrial infrastructure story, as well as the visionary leadership, strong institutions, strategic pragmatism, and the constant innovation to stay ahead.

May you enjoy reading about Singapore's economic journey.

Philip Yeo  
Chairman, SPRING Singapore





# Preface

The Centre for Liveable Cities (CLC) research in urban systems tries to unpack the systemic components that make up the city of Singapore, capturing knowledge not only within each of these systems, but also the threads that link these systems and how they make sense as a whole. The studies are scoped to venture deep into the key domain areas the CLC has identified under its Liveability and Sustainability Framework, attempting to answer two key questions: how has Singapore transformed itself to a highly liveable city within the last four to five decades; and how Singapore can be resilient to new and more complex forms of urban challenges and remain at the forefront of urban development and management. *Industrial Infrastructure: Growing in Tandem with the Economy* is the third in the Singapore Urban Systems Studies Booklet Series.

The research process involves close and rigorous engagement of the CLC with our stakeholder agencies, and interviews with Singapore's urban pioneers and leaders to gain insights into development processes and distil tacit knowledge that have been gleaned from planning and implementation, as well as governance of Singapore. As a body of knowledge, the urban systems studies, which cover aspects such as Water, Transport, Housing, Planning, Industry and Environment, expound not only the visible outcomes of Singapore's development, but reveals the complex support structures of our urban achievements.

The CLC would like to thank EDB, JTC, 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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# 1

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## Introduction

Industrialisation drove the engine of Singapore’s rapid economic development since the city-state achieved internal self-government in 1959 from its British colonial masters. It precipitated the departure of Singapore from being a traditional entrepôt economy to one founded largely upon manufacturing-based industries.

In 1965, Singapore became an independent country and the economy has continued developing through the trajectory of export-oriented industrialisation. The nature of the economy has evolved from a labour-intensive phase in the 1960s to a skill-intensive phase in the 1970s, a capital-intensive phase in the 1980s, a knowledge-intensive phase in the 1990s, and since 2000, an innovation-driven one. As the economic structure moved upstream towards more sophisticated and higher value industries, Singapore’s GDP increased exponentially in parallel. Today, the GDP per capita is almost \$60,000, or thirteen times that in 1961, in real terms.<sup>1</sup>

The nature and quality of Singapore’s industrial infrastructure has also correspondingly evolved. It can be said that Singapore’s economic foundations were laid in hard infrastructure — first in fairly standard factories and workshops, and later, as the economy moved up the value chain, with ever more responsive and specialised industrial parks. (See **Appendix A** for a policy timeline on Singapore’s economic and industrial infrastructure development). Economic growth in Singapore has developed in tandem with the industrial infrastructure landscape, where the latter is by and large a physical manifestation of economic priorities (see **Appendix B** for some of the key governance tools of Singapore’s industrial infrastructure system). In their book *Four Decades of Transformation: Land Use in Singapore, 1960–2000*, authors Wong Tai-Chee and Adriel Yap noted that, “it is fair to suggest that the Singapore government, which has a firm control over the supply of industrial land, is equipped with a very powerful tool to translate its industrialisation policy into the intended morphology, shaping the landscape to a substantial scale.”

In short, the tight relationship between Singapore’s economic strategy and industrial infrastructural development has contributed greatly to the transformation of Singapore from Third to First World.

**Endnote**

1. Lee, H. L., (Speech presented at the EDB 50th Anniversary Gala Dinner, Singapore, August 1, 2011).

# 2

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## Paving the Way for Industrialisation

### 2.1 TRANSFORMING THE COLONIAL TRADE ECONOMY

Strategically located along the major trade routes and naturally blessed with a deep harbour, Singapore was founded by the British as a key trading post in 1819. The implementation of free port status and free trade by the British authorities swiftly sealed Singapore's position as a flourishing port in the region. Singapore specialised in the import and re-export of commodities like rubber, tin and spices. Entrepôt trade was essentially the bedrock of its economy throughout the colonial period.

In the post World War Two era however, there were tremendous changes in Singapore's socio-political situation. Its population growth rate of 4.4% per annum between 1947 and 1957, was one of the highest in the world then. This meant that there was a significant increase in school-leavers entering the job market each year.<sup>1</sup> The unemployment rate then was high, hovering above 10%.

By 1959, Singapore had achieved internal self-governance from the British. There was a pressing urgency for the new government to provide jobs quickly, in face of the political chaos and social unrest. Singapore's entrepôt trade economy was unable to grow fast enough to generate sufficient employment. Furthermore, neighbouring countries were developing their own ports and had begun to move into direct importing and exporting. It soon became clear that this heavy reliance on entrepôt trade was not the way forward for Singapore.

However, unlike other developing countries at that time, developing an agricultural sector was not a viable option

*"In short, industry would modernise and enrich . . . [and it] would not only generate economic growth but also help to bring about a rapid transformation of social attitudes to those more consistent with needs of modernising societies."*

*Dr Goh Keng Swee<sup>2</sup>*



for Singapore due to its limited land size. Also, Singapore has no natural resources. Dr Goh Keng Swee, Singapore's first Finance Minister and the person widely considered the economic architect of Singapore, thus decided that industrialisation was the solution.

The purpose of industrialisation was to create another facet of the economy that could generate jobs quickly, to complement trade, with each helping the other grow.<sup>3</sup> It would also be a means of transforming Singapore into a modern city-state.

## 2.2 EARLY INDUSTRIAL AND INFRASTRUCTURAL FOUNDATIONS

In 1959, Singapore was in a relatively good state for industrialisation. As a key British colony, it already had an important and strategic seaport in the region. Its established connectivity with the world as a significant trade hub was something that could be leveraged on. An international airport was completed at Paya Lebar in 1955 and the Singapore Telephone Board, the early provider of telecommunication services, was established as a statutory board that same year. This background of good economic and communication infrastructure greatly facilitated Singapore's industrialisation process, providing the basis for its successful transformation into the global business, trade and communications hub it is today.

Industrial development during the colonial period was limited, as the British did not want to start any industries in Singapore that would be in competition with their own back home. Still, some semblance of a manufacturing sector had emerged by the 1950s, albeit mostly in a sporadic and random manner. Planned industrial estates were rare at that time though they did exist. The Colonial Development Corporation built an industrial estate at Bukit Timah in 1951 for small and medium scale industries, supported with services and facilities. A second estate at Alexandra was built by the Singapore Improvement Trust,<sup>4</sup> which was responsible for town planning. In 1957, the Singapore Industrial Promotion Board (SIPB) was established.

Upon achieving internal self-government in 1959, the new government quickly sought help for its fledgling economy from the United Nations. Led by the Dutch industrial economist Albert Winsemius, the United Nations Development Programme (UNDP) team arrived in Singapore in 1960. Their survey culminated in a document called "A Proposed Industrialization Programme for the State of Singapore", or more commonly known as the Winsemius Report that was to greatly influence the nation's industrialisation blueprint. Essentially, the report substantiated Dr Goh's stand that industrialisation would be key to generating sufficient employment. The survey found that the already low level of manufacturing in Singapore had decreased in the 1950s due to the unstable political and social climate, and this situation was of concern in the context of economic development. The report thus recommended the creation of "a dynamic export industry which can compete in export markets both in quality and price"<sup>5</sup> — in other words, espousing export-oriented industrialisation. The report also recommended that Singapore should institute infant industry protection measures;

impose tariffs against imports where feasible, but without hurting entrepôt trade; and focus on locally manufactured products for large-scale government public infrastructure construction. These measures veered towards the import-substitution approach. The report also included recommendations on a series of investment, trade, capital, labour and industrial policies.

Two other proposals in the Winsemius Report would prove to be particularly crucial in the success of Singapore's economic development: first, the establishment of the Economic Development Board (EDB) to drive the industrialisation programme; and second, the development of industrial estates, in particular in Jurong, to provide the necessary physical landscape for industrialisation.

From 1960 to 1965, Singapore's initial industrial strategy was largely based on the import-substitution approach with limited export-oriented features. The emphasis was on the protection of local industries — import tariffs and quotas were imposed on a wide range of consumer products that were domestically manufactured — to give time for the infant industries to develop and thus enable industrialisation to take off effectively. However, Singapore's government was also keenly aware that embarking upon industrialisation was useless without a market that could absorb the products manufactured. As the tiny domestic market was simply unable to meet this need, the solution was to use Malaysia as a hinterland through a political merger that materialised in 1963. This concept of the common market was promoted heavily by EDB to the public as crucial to Singapore's economic development. Mr S. Dhanabalan, a former Minister for Trade and Industry, summed up its significance, explaining that Singapore, being “a small country with no natural resources or significant domestic market, [the common market] was our most important precondition for success.”<sup>6</sup>

### **2.3 POST-INDEPENDENCE STRATEGY: COMMON MARKET TO GLOBAL MARKET**

However, the separation of Singapore from Malaysia in 1965 shattered this promise of the common market. Without a sizeable domestic market in Singapore, import-substitution industrialisation would not work. Thus, this necessitated the turn of Singapore's strategy to full-fledged export-oriented industrialisation. Mr Ngiam Tong Dow, a pioneer civil servant who had also served as chairman of EDB, recounted that “in one stroke, [the government] removed all the duties and tariffs”<sup>7</sup> upon gaining independence on 9 August that year. This meant that the local manufacturers were no longer protected from foreign competition. It proved to be a very painful period for both the manufacturers and EDB which had convinced them to go into manufacturing in the first place. However it was a necessary choice EDB had to make, in order for a small economy like Singapore to survive and be competitive.

The situation was compounded by the British announcement in 1967 that they would withdraw their troops from Singapore for good. This was a big blow, as the move would result in 30,000 direct job losses, and 40,000 more indirect ones.<sup>8</sup> As such, Singapore's drastic switch to export-driven

industrialisation that would make the economy dependent on the forces of the global economy was necessitated by the circumstances. Mr Ngiam explained matter-of-factly that “though it was tough at that time, separation from Malaysia and the withdrawal of British forces sent a torrent of ice-cold water that braced us for global competition.”<sup>9</sup>

Freed from the tariff alignment policies of the Malaysian common market, Singapore embarked upon a free enterprise economy that was run on the basis of profit-driven competition. It was an extension of Singapore’s heritage as a successful free trade port, which was inextricably tied to the global market. Dr Goh argued that having an open competitive system, where business success was not influenced by political interests, was the key to secure efficiency and thus maintain Singapore’s outstanding trading position.<sup>10</sup>

However, it was never really a pure *laissez-faire* system where everything was left to market forces. The government “assumed an extensive and high-level involvement in industrial development”<sup>11</sup> where it led the way as the primary investor and entrepreneur in the export-oriented free enterprise economy. The inherent nature and circumstances in Singapore were not wired for free-market enterprise. Singapore lacked natural resources, industrial skills and expertise, managerial abilities and structures, as well as a strong indigenous industrial capitalist class that could spearhead export-driven industrialisation. The local merchants had traditionally been focused on trade and service activities and thus had little inclination to initiate a switch to become industrialists. State intervention also helped circumvent coordination problems, particularly in an economy with a poor industrial base.

First, the government set up strategic state institutions to spearhead economic growth. Of these, EDB was the principal agency. It was established in 1961 to attract investments by creating and promoting Singapore as a pro-business environment, replacing the largely ineffective SIPB, which was hampered by the limitation of its scope, funds and manpower. As a one-stop agency for investors, EDB provided them assistance in training, loans and tax incentives, industrial land and infrastructure. In 1968, two other key state institutions were carved out from EDB. The Jurong Town Corporation (JTC) took over the land and estates development and management of the Industrial Facilities Committee, essentially providing industrial land and infrastructure to investors. The Development Bank of Singapore Limited (DBS) took over the industrial financing functions.<sup>12</sup>

Secondly, from the 1960s, the government established government-linked corporations (GLCs) in vital, large-scale industries which the private sector did not have the capacity to effectively participate. These were typically in the heavy industries, communications, financial, port, and aviation sectors. Examples include National Iron and Steel Mills (now NatSteel), Singapore Airlines (SIA), Neptune Orient Lines (NOL), SembCorp, and SingTel. Although state-owned, there was little governmental control and supervision in how the GLCs were run. The GLCs were expected to be internationally competitive, which Dr Goh ensured by forcing them to list on the stock exchange.

To complement the state-owned enterprises, the government looked to foreign capital and expertise. EDB began its relentless pursuit of investments from foreign MNCs, and Singapore’s economy has since been characterised by a significant dependence on them.

## 2.4 PLANNING FOR INDUSTRIAL INFRASTRUCTURE

In conjunction with the economic take-off, the government also started to put in place the framework for financing and land acquisition to support industrial infrastructure development.

### Financing Infrastructure

The Development Plan of 1960–1964 recognised that infrastructure development was the key to accelerate industrialisation. It allocated the majority of the developmental expenditure to economic purposes, for EDB to develop industrial estates and to improve public utilities. The plan also advocated the prudent financing of infrastructure, primarily by domestic financing or self-funding, through raising loans and from revenue surpluses. Only a small portion would come from foreign grants.

In practice, the plan was followed closely. According to Mr Ngiam, Singapore had always practised fiscal rectitude and only borrowed for productive purposes, namely, to grow the economy,<sup>13</sup> that is, for financing infrastructure. In the early years, modest sums were borrowed from foreign sources like the World Bank and the Asian Development Bank. However, as a rule Singapore was always strictly conscientious not to spend more than the revenue it earned.

EDB was given a starting grant of \$100 million as its capital fund, and when JTC was carved out in 1968 to take over the lands and estates management functions, all its remaining liquid assets were transferred back to the government.<sup>14</sup> A loan was then given to JTC. JTC has long repaid the loan<sup>15</sup> and is a self-financing entity today.

### Acquiring and Pricing Land

The government needed to acquire land quickly and affordably to build the infrastructure to support industrialisation. The Land Acquisition Act was enacted in 1967 to enable the government to acquire private land for public purposes like building public housing and industrial infrastructure. Landowners were compensated at pre-development value or the raw price of the land.

Although seemingly draconian, it was a powerful tool and one the government deemed necessary. In the early years JTC was empowered to carry out land acquisition under the Act. This enabled JTC to move quickly.<sup>16</sup> Without these provisions, industrialisation would have been hampered. Under the Act, JTC was able to buy much land cheaply, which greatly aided it to be self-financing in the long term. In the initial years, the land pricing policy followed the “sharing prosperity, sharing misery” approach, where industries were charged only 6% of the annual land value and this was fixed for five years, after which the value would be revised. However, any increase due to development would be capped at 50%.<sup>17</sup> Conversely, if the industrial estates did not succeed, prices would drop thus the misery would be shared. This approach helped the companies as they could spend their scarce capital on machinery, equipment and the construction of factory buildings, instead of on high premiums for the land.

JTC retained this approach until the 1980s, when the Ministry of Finance instructed JTC to return all undeveloped land that was surplus to its immediate needs to the state. Since then, JTC has had to repurchase land for industrial development at current market rates.<sup>18</sup> Through benchmarking with its international competitors, JTC prices the land competitively for companies that are supported by the economic agencies and qualify for direct allocation. Today the execution of the Land Acquisition Act can only be done by the Singapore Land Authority (SLA).

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18. Ibid., 185–186.

# 3

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## Evolution of Economic Policy and Industrial Infrastructure Development (1960 to Date)

This section looks at the evolution of economic policy from the 1960s to 2000s and the corresponding developments in industrial infrastructure.

### 3.1 CREATING AN INDUSTRIAL ECONOMY (1960s)

Singapore's foundational decade of the 1960s was a harsh period fraught with multiple challenges, and where survival was of utmost importance. Serious economic problems were exacerbated by the surrounding political and social tumult. In addition, Singapore had no natural resources, little capital and poor industrial capabilities. However, what Singapore did have was a leadership that took a pragmatic approach in establishing the framework and mechanisms for the city-state's economic development.

The leaders saw that it was a propitious time to enter into export-led industrialisation. Companies from the developed economies were looking to relocate their low-end manufacturing operations to cheaper locations abroad, and three of the largest "reservoirs of labour" in Asia — China, India and Indonesia — were not open to the global economy yet.<sup>1</sup> The Economic Expansion Incentives Act passed by the Singapore government in 1967 allowed foreign companies to apply for pioneer status on new investments. "Pioneer status" companies enjoyed five years of tax concessions. EDB did intensive promotion work to attract foreign investment, as well as provide a system of basic industrial training for workers.

Job creation was then the foremost priority of economic development, and as Mr Ngiam put it, Singapore "welcomed any industry, high tech, low tech, or no tech."<sup>2</sup> The early phase of economic

development focused on low-skilled labour-intensive manufacturing, such as textiles, toys, mosquito coils, shipbuilding, and most notably the assembly of consumer electronics. This provided a large volume of jobs.

## Infrastructure Developments: The First Industrial Township

Building an industrial township was a proposal from Dr Goh Keng Swee as well as a recommendation of the 1961 Winsemius Report. It was a bold plan to transform 5000 acres of rural hills and swamplands in Jurong into a large industrial estate with its own port and railway connections.<sup>3</sup> Jurong was chosen as it was the least-populated area on the island and its deep-water coastline would be suitable for a port. While the creation of this pioneer industrial estate was necessary for industrialisation to take off, it was still considered a risky venture as Jurong was unknown rural territory. There was concern that the ambitious project could potentially end up as a huge white elephant. In fact, Dr Goh joked that it would be known as “Goh’s Folly” should the project fail, underlining the enormity of what was at stake.

However, having this township with proper industrial infrastructure was necessary for gaining investor confidence. Up to then, Singapore was a relatively unknown and untested country. At the start of Singapore’s industrialisation programme, the inherent difficulties were that it lacked natural resources, a domestic market and industrial skills.

In the early days, EDB and JTC had to build ahead of time, so that the infrastructure would be ready when the investors came. While EDB pursued investors, JTC and other government agencies worked round-the-clock to level the hills, fill in the swamplands and resettle the farmers. Factories, public utilities, roads, drains, sewers, housing and amenities were built with great speed. By 1963, Jurong had a completely new look, and the construction of Jurong Port commenced.<sup>5</sup> Jurong was developed as a self-contained township. Mr David Tan, current Assistant CEO of JTC, explained that the aim was to provide jobs for people at that point in time and also provide a place for people to stay.<sup>6</sup> Outside Jurong, in residential towns like Kallang, Tanglin Halt and Redhill or at the fringe of the CBD, the government built smaller industrial estates with multi-storey flatted factories for light industries.

Essentially, prepared land and generic standard factories defined the industrial infrastructure of the 1960s. These were sufficient to serve the industries that the economy was attracting during the early stage of economic development. Speed and efficiency were vital to kick-start Singapore’s economic growth. The quick start-up and plug-and-play industrial environment delivered by JTC was important in providing a competitive edge.

*“The quality of our infrastructure becomes particularly important because, to some extent, it compensates for the other ‘weaknesses’. Thus the aim from the start has been to develop industrial infrastructure that can act as a differentiating advantage for Singapore.”<sup>4</sup>*

*Manohar Khiatani,  
CEO of JTC*

### 3.2 BUILDING UP SKILLS AND THE PACE OF INDUSTRIALISATION (1970s)

By the early 1970s, the unemployment problem was resolved. Singapore reached full employment in 1972, with the double-digit unemployment rate a decade earlier dropping to just below 3%.<sup>7</sup> This can be largely attributed to the manufacturing sector. In 1960, manufacturing made up just 13.2% of GDP. By 1980, this had increased to 22.7%. As the largest beneficiary of the rising influx of foreign capital, it quickly shaped up to be the most dynamic growth sector of the economy. Also, the passing of the Employment Act in 1968, and the establishment of a tripartite relationship between the government, employers and workers in 1972, had quelled labour unrest.

**FIGURE 1 Sector Contribution to GDP at 1968 Prices, 1960–1980**

Sector	1960	1970	1980
Manufacturing	13.2%	19.7%	22.7%
Trade	33.6%	30.1%	24.5%
Transport & Communications	14.0%	11.6%	17.7%
Financial & Business Services	11.7%	14.1%	15.4%
Others	27.5%	24.5%	19.7%

Source: EDB 1980/1981 Annual Report

Singapore's industrialisation programme was on track, and the pace of industrial growth accelerated rapidly in the 1970s and the early 1980s. Singapore went through a period of building the skills of the workforce to equip it for employment in the higher value industries. Mr Tan Choon Shian, the current Deputy Managing Director of EDB, highlighted that the upgrading of skills was "a key point of differentiation that EDB went into in the 1970s."<sup>8</sup> The government partnered both foreign industry leaders and countries to carry out the training. Government Training Centres (GTCs) were set up in collaboration with the MNCs like Philips, Rollei and Tata. Technology institutions were jointly established with Japan, Germany and France.

The economy shifted from the labour-intensive industries towards skill- and capital-intensive industries. There was a strong push towards precision engineering and electronics (manufacture of PCs, printed circuit boards, disk drives, watch movements, etc) and the petrochemical industries. Simultaneously, in typically heavy or large-scale industries where the private sector lacked the capital or expertise to invest in, GLCs emerged. These included Singapore Airlines, Sembawang Shipyard (converted from the British naval base), and the Petrochemical Corporation of Singapore.



## Infrastructure Developments: Expanding the Industrial Landscape

As the pace of industrialisation accelerated in the 1970s through the early 1980s, there was a corresponding expansion in the number and size of the industrial estates. This was reflected in the Land and Building Use Survey done in 1982 by the Planning Department of the Ministry of National Development, showing a 359.4% increase in land used for industrial purposes between 1967 and 1982 (Figure 2).

**FIGURE 2 Land Use Change in Singapore, 1967–1982**

Main Land Use Categories	1967 Land Area (ha)	1982 Land Area (ha)	% Change
Residential	7485	8715	+16.5
Industrial	730	3345	+359.4
Transportation	2655	7455	+180.8
Swamp/Water/Wooded Area	8350	5930	-29.0
Agricultural	14280	8100	-43.3
Vacant (incl. under clearance)	9385	9320	-0.7

Source: MND 1983 Annual Report (Note: Figures are rounded to the nearest 5.)

During this period, Jurong Industrial Estate was significantly enlarged through land reclamation. The quality of the residential and recreational aspects of the estate was also improved, bringing the vision of Jurong as a self-contained industrial town into maturity. In some residential areas, the Housing Development Board (HDB) created integrated housing estates with 20% of the land set aside for industrial use. JTC developed and managed about half of the industrial land while HDB developed the remainder.<sup>9</sup> These were usually for cottage industries that had been affected by HDB's land acquisition.<sup>10</sup> New industrial estates were located in the high-density housing estates of Toa Payoh, Ang Mo Kio and Ayer Rajah, where the factories could tap on the availability of labour.

Industrial estates were also created for designated industries. For example, the strong push in the petrochemicals industry led to the development of the Petrochemical Complex on Pulau Ayer Merbau, where site formation work began in 1976. Other large-scale industrial estates were established in outlying areas on the mainland — Sungei Kadut and Kranji were for the woodworking industries; Loyang, being near Changi airport, housed the aviation industries.

### **3.3 REINVENTING THE ECONOMY AFTER A WATERSHED RECESSION (1980s)**

Singapore's growth had then been fuelled by an excessive dependence on cheap labour. In the 1960s, wages were low, in correspondence to the low skill level of the workforce. The National Wages Council was set up in 1972 to ensure orderly wage adjustments and to introduce incentives for improving productivity. However the global recession in 1974 put the upgrading plan on hold and made it more expedient to pursue a cautious wage policy instead.<sup>11</sup> This enabled high economic growth to continue unabated "almost regardless of the state of the rest of the world [where] despite two oil crises and global recessions, the Singapore economy grew, robustly and apparently inexorably. A bad year meant GDP growth of 5%. A boom year meant 15% growth."<sup>12</sup> However, the economy was not growing qualitatively. In the immediate circumstance, it created a tight labour market, where it soon necessitated the inflow of foreign workers from neighbouring Malaysia and Thailand to fill the labour-intensive industries.

In 1980, Mr Goh Chok Tong, then Minister for Trade and Industry, launched the so-called Second Industrial Revolution with the aim to "develop Singapore into a modern industrial economy based on science, technology, skills and knowledge."<sup>13</sup> It was a necessary structural shift to avoid competing with the regional countries that were opening up and thus could offer foreign MNCs plentiful labour at lower costs than Singapore.

In order to restructure the economy, the government had been pursuing a wage correction policy from 1979 to 1981 that raised wages significantly. The aim was to push companies to upgrade their operations and labour productivity to justify the higher wages, and force out companies dependent on low-cost low-skilled labour which were perceived to be hindering industrial development. However, what this policy created instead was a structural problem in the economy as productivity gains lagged behind the wage increases.

The prolonged global depression from the 1979 oil crisis slowed down global demand, hitting the foreign MNCs in Singapore hard. It particularly affected the oil refining, petrochemical, shipbuilding and ship-repairing industries, which accounted for a quarter of Singapore's manufacturing sector. Singapore's high-wage policy and escalating costs only exacerbated the situation, raising operating costs without a corresponding increase in productivity. Many companies chose to relocate to cheaper locations instead. The structural rigidities in the economy had resulted in Singapore losing its competitiveness. Consequently in 1985, Singapore plunged into its first recession since independence.

The recession was a turning point in Singapore's economic development. It was the end of two-decades of easy growth.<sup>14</sup> It gave the government impetus to restructure and reposition Singapore's economy. Then Minister for Trade and Industry, Mr Lee Hsien Loong led the Economic Committee which was quickly convened to study the causes of the recession and recommend new directions for the future of the economy.

The recession highlighted Singapore's fragile dependence on the vacillating flow of foreign capital and a few key industries. Also, rigidities in Singapore's economy were the root causes of the domestic problems. The committee concluded that a convergence of both external and internal adverse

circumstances had led to the recession. The government began to aggressively implement interim cost-cutting measures to restore the country's competitiveness. It froze wages, lowered employers' contributions to the Central Provident Fund (the national social security savings plan) from 25% to 10%, reduced taxes, and influenced interest rates downwards.

Beyond these measures, the most important change was a new business strategy. Dr Tan Chin Nam, who was then the Managing Director of EDB, stressed that "what was more important was the articulation of the twin engines approach, and the total business strategy, of not just manufacturing but also services."<sup>15</sup> This was one of the key shifts recommended by the Committee. EDB thus repositioned its pitch of Singapore as a "global city with total business capabilities" to investors. EDB promoted the concept of establishing operational headquarters (OHQ) in Singapore to companies, launching the OHQ tax incentive scheme in 1986. This ensured that the services sector would be developed as the second engine of the economy. Dr Tan described this as a milestone, in the building up of "services in support of manufacturing, and in support of the subsequent evolution of Singapore to become a knowledge and innovation economy."<sup>16</sup> Another change was that Singapore needed to diversify its economy and embark upon regionalisation, where GNP and not GDP would be the new measure of economic success — thus moving from "Singapore, Inc. to Singapore Unlimited."<sup>17</sup>

More attention was also turned towards nurturing the domestic enterprises. The Local Industry Upgrading Programme was introduced in 1986 to link up the local small-medium enterprises (SMEs) to the MNCs, as suppliers and as providers of their outsourcing needs. This was followed by the establishment of the Small Enterprise Bureau that same year, and the launch of the SME Master Plan in 1989. With all these swift efforts to restore equilibrium and reinvent the economy, it recovered within eighteen months.<sup>18</sup>

## **Infrastructure Developments: Creating the Business Parks (1980s)**

In 1980, JTC released a 10-year Master Plan to prepare for new industrial landscapes and infrastructure that were conducive to the higher value industries, as the economy moved into a capital and technology intensive phase of industrialisation.

This gave rise to a new industrial typology — the business park. The first was Singapore Science Park I near the National University of Singapore, which was launched in 1980. The concept was about creating a science and technology hub in a park-like setting, located in close proximity to tertiary institutions to facilitate collaboration between industry and academia. However, the malaise that led to the outbreak of the 1985 recession stalled efforts to upgrade the economy. JTC temporarily suspended industrial developments to prevent an oversupply in the market. It also reduced rents and gave rebates to help companies weather the recession.

In the aftermath of the recession, Singapore's economy switched to a twin engine approach of manufacturing and services. Dr Tan explained that this had a significant impact on the industrial land use strategy, as services now had to be accommodated as well. Thus the business park typology,

which could accommodate a combination of manufacturing activities and high level services, dovetailed well with this new economic positioning.<sup>19</sup>

### **3.4 PURSUING A KNOWLEDGE-BASED GLOBAL ECONOMY (1990s)**

After recovery, Singapore intensified its efforts to become a knowledge-based global economy. The 1991 Strategic Economic Plan outlined the vision to attain “the status and characteristics of a first league developed country.”<sup>20</sup> The backdrop to this strategy was the onset of globalisation, technology advancements and the liberalisation of emerging markets like China and India. With outsourcing made possible and an abundance of low-wage workers released into the global economy, Singapore needed to move its economy upstream to ensure its competitive edge. It could no longer compete based on a low cost advantage. As such, the government led the move to build up the technology base, as well as increase industrial training and education for the workforce.

Singapore’s cluster development strategy in the 1990s was a key game changer. The rationale was that mutually supporting related industries were to be identified to form clusters and compete on that basis. Thus, cluster development plans could be formulated, focusing on shared core capabilities and infrastructural facilities between industries within each cluster. The strength of these synergies would add value to potential investors, thus sharpening Singapore’s competitive edge. EDB unveiled a \$1 billion Cluster Development Fund in 1993 to “catalyse the development of indigenous industries in the high-growth clusters”<sup>21</sup> of electronics, petrochemicals, precision engineering, as well as newer high-tech industries like Biomedical Sciences (BMS), which have a strong emphasis on R&D. In the services sector, Singapore built up its capabilities as a financial, logistics and transport hub.

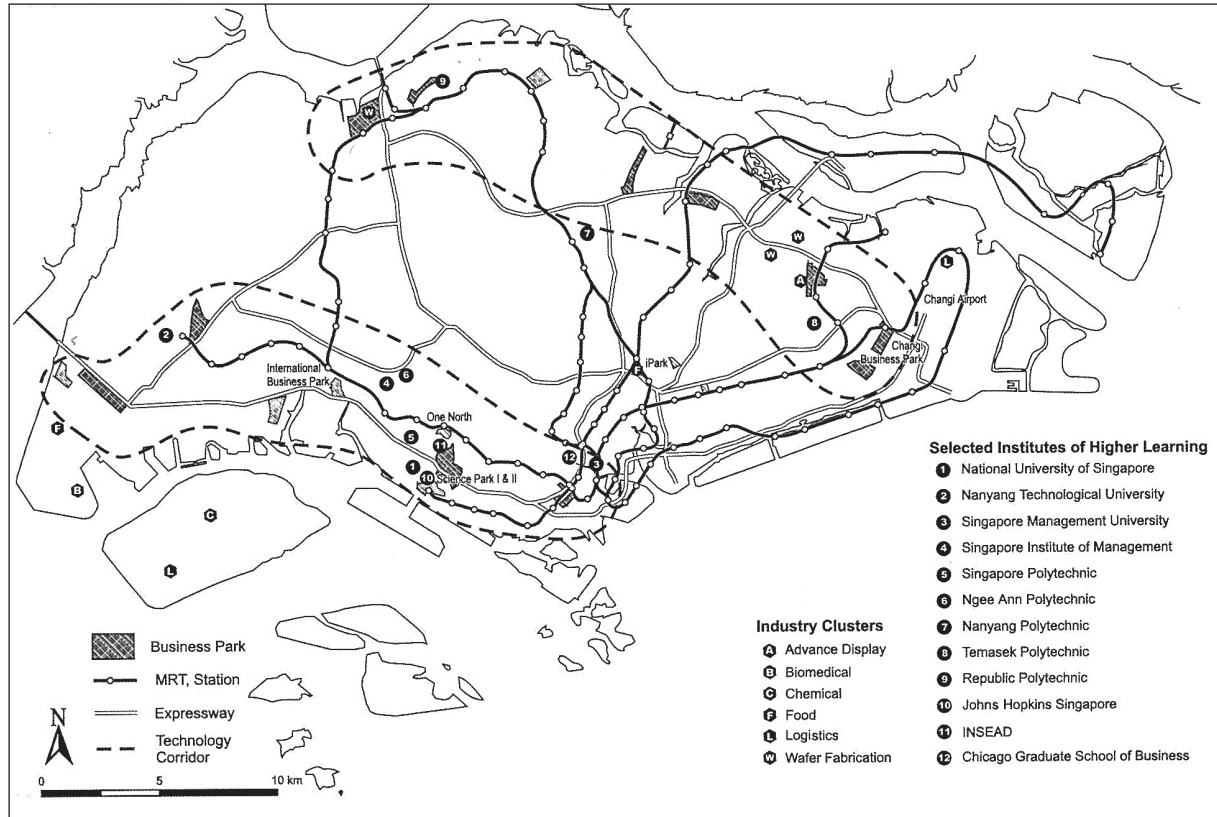
As a complement, Singapore looked to expand its economic space through regional expansion into the Asian markets. In this way, Singapore was able to offer investors a holistic package that allowed them to site parts of the operations which required engineers, managers, communications and financing in Singapore, and the more labour and land intensive operations in the neighbouring countries. A tangible outcome of this strategy was the Growth Triangle, which was established between Singapore, the Indonesian Riau Islands (specifically Batam and Bintan) and Johor in Malaysia, in the early 1990s. In the same period, Singapore also began to export its expertise and services abroad. A notable example is the Suzhou-Singapore Industrial Township, which JTC helped develop as part of a government-to-government collaboration between China and Singapore.

### **Infrastructure Developments: Specialised Industrial Parks**

Singapore’s push towards a knowledge-based economy was already apparent in the 1991 Concept Plan (Singapore’s strategic land-use plan). It marked out two technological corridors on the island

along which industrial parks conducive to incubating knowledge-driven industry clusters would be constructed.

FIGURE 3 1991 Concept Plan (Business Parks, Industry Clusters, Institutes of Higher Learning)



Source: Wong Tai-Chee and Yap Lian-Ho Adriel, *Four Decades of Transformation: Land Use in Singapore, 1960-2000* (Singapore: Eastern University Press by Marshall Cavendish, 2004). Adapted from the 1991 Concept Plan.

The Concept Plan also made provisions for the creation of the future Jurong Island through the amalgamation of seven southern islands, as a strategic chemicals hub.

The implementation of the cluster development strategy illustrated one of the strongest correlations between economic and industrial infrastructural development. JTC moved into creating specialised parks that were dedicated to particular clusters of industries. As the new knowledge industries were largely focused on R&D, specialised facilities were necessary to meet their needs. For example, wafer fabrication plants required an abundant clean water supply, had to be sited away from polluting activities, and needed large tracts of vibration free land as several plants had to be built as a cluster to be economically viable. Mr David Tan explained that the crux of specialised parks is industry integration, which brings two important benefits: first, to integrate different parts

of an industry together, companies that are related in the whole value chain, so that they can then enjoy the economies of scale; and second, when companies are integrated, they can outsource their facilities or non-essential services to a third party so that they can then focus and concentrate on their core business.<sup>22</sup>

Also, by the 1990s JTC had shifted from building industrial infrastructure “ahead of time”, towards building “just in time”. JTC would do a master plan for the estate and build it in phases to meet demand for the space. This allowed JTC the flexibility to reallocate land to other industries should the situation change. Singapore was able to take this approach as the EDB and JTC partnership, through its track record of delivering what was promised, had already built up a good reputation among investors for providing a quick start-up environment. As such, there was no longer a pressing need to build ahead to convince potential investors. This “just in time approach” was more challenging but it was a necessary shift that helped JTC better respond to changes in the global economic landscape. JTC also had to go beyond just providing efficient infrastructure and move towards optimising land use and providing innovative industrial infrastructure solutions,<sup>23</sup> in tandem with the move of the economy to the knowledge-intensive phase.

In particular, these strategies were aptly illustrated by the unprecedented Jurong Island project, which was developed to be a “chemicals island” from the 1990s onwards. Philip Yeo, then Chairman of EDB, challenged his officers to work out a plan to create a “chemicals island”. By the early 1990s, the daring plan to build a multi-tenanted complex, owned and operated by the industry’s top players and supported by common pipeline service corridors and third-party service utilities and logistics providers<sup>24</sup> was conceptualised. The idea was to capitalise on horizontal and vertical linkages within the whole cluster, where “the output from one plant becomes the input for another, allowing them to feed off each other symbiotically.”<sup>25</sup> This would bring much efficiency, convenience, costs and space savings — giving the companies great advantage when competing in the global market. (See **Box Story 1.**)

**BOX STORY 1****BUILDING A CHEMICALS ISLAND, JUST IN TIME**

The petroleum refining industry has a long history in Singapore — Shell opened the first refinery on Pulau Bukom in 1961 — and was contributing a significant 20% to 30% to the manufacturing sector. However, after the 1985 recession, there was an urgent need for Singapore to move towards higher value-added industries and to diversify the economy. EDB identified the chemicals cluster (petroleum, petrochemicals and specialty chemicals) as an industry it would pursue strongly.

Meanwhile JTC was facing a constraint of industrial land, and thus began to reclaim land off Tuas. JTC soon realised that the relatively low cost of reclamation meant that this was an economically viable option to exploit further. Soon the idea of amalgamating the seven southern offshore islands was born.<sup>26</sup>

Jurong Island was also a clear illustration of how JTC built infrastructure “just in time”. EDB had begun its intensive promotion effort with the top players in the international chemicals industry while the land reclamation was still in progress. It was a high-risk venture and a colossal task, much like Jurong Industrial Estate in the 1960s. However there was a big difference. In the case of Jurong Island, potential investors were being offered the purchase of “plots of land for their plants, often when the sites [were] still under the sea.”<sup>27</sup> Previously, JTC would have already built up the whole industrial estate. However, many companies made a bold commitment to Jurong Island based on the EDB and JTC’s successful track record, as well as the trust and good relationships that EDB had nurtured over the years.

While take-up was very slow in the early years, a breakthrough came with a US\$100 million plant investment in 1995 by Celanese Chemicals. This opened the doors to many more investments and soon the phases of development were fast-tracked for early completion. Despite the daunting deadlines, JTC managed to deliver just in time. When the President and CEO of Teijin Polycarbonates flew in to see his site in December 1996, it was still two-thirds underwater, even though construction of the plant was to commence in thirteen months. However, when he returned six months later, the site was already fully reclaimed.<sup>28</sup>

### 3.5 REMAKING SINGAPORE TOWARDS INNOVATION (2000s ONWARDS)

Singapore's industrial development was progressing steadily upstream. The economy recovered from the 1985 recession and was growing at an average rate of 8.5%. However, the second recession hit in 1997 as the Asian Financial Crisis erupted. A series of Asian currencies had declined sharply due to intensive speculation, and stock and property markets plunged due to the widespread panic. Singapore, with its significant trade links with the regional economies, inevitably suffered. The economy contracted by 2.1% due to a slowdown in both global and domestic demand, and there was a massive loss of jobs.

Recovery started in 1999 but was unfortunately hampered by a succession of events on the global stage that followed — the bursting of the dot-com bubble in 2000, and the September 11th terrorist attacks in 2001. The latter hurt the US and global economy heavily and Singapore fell into its third recession in 2001. The economy rebounded quickly again due to its strong fundamentals, but in 2003 the outbreak of the severe acute respiratory syndrome (SARS) and the Iraq War led by the US, put a damper on the already weak growth.

MTI thus set up the Economic Review Committee in 2001, which released its report in 2003. The report noted that Singapore was at another turning point, challenged by a maturing economy, globalisation and rapid technological advances, strong competition from the rise of China and India, and an increasing unstable world. In order to remain competitive in such a complex landscape, the report recommended that Singapore be remade into a globalised and diversified economy, and a creative and entrepreneurial nation.

The strategy was to build on Singapore's strengths — its talent, a strategic geographical location, and its well-established connectivity through the port, airport and telecommunications services — to create an “enterprise ecosystem” of both large companies and innovative start-ups to generate new knowledge and capabilities.<sup>29</sup> Singapore would pursue innovation-driven industries, like biomedical sciences (BMS), life sciences, information communications (infocomms) and media, clean technology, and environment and water management. EDB launched the Global Entrepolis initiative in 2003 with this positioning: “the 6,000 MNCs and 100,000 SMEs operating in Singapore are a rich reservoir of expertise and experience, from which international corporations and businessmen can tap to grow their businesses, discover new technologies, build new alliances, and find new opportunities.”<sup>30</sup>

In this decade, the rise of Asia as an economic growth engine has been a key paradigm shift in the global economy. In 2008, the global financial turmoil occurred as a result of the subprime mortgage crisis that originated in the US. What was significant was that the ensuing recession, which had the heaviest impact on the G3 economies, accelerated the shift in attention by MNCs to Asia and other emerging economies. This meant that Singapore needed to strategically rethink the way to position itself in this highly favourable context.

In 2009, the government set up the Economic Strategies Committee to chart the way forward for Singapore's economy. It released its report the following year. The key recommendations were to achieve higher productivity growth through skills and innovation, to be an energy smart economy,



enhance land productivity, and build both a distinctive global city and an endearing home. The government would also continue to invest in developing R&D capabilities, nurturing local talent as well as attracting global talent.

Dr Beh Swan Gin, Managing Director of EDB from 2008 to mid 2012, elaborated on the thinking behind the recommendations. There were three pivotal shifts, as explained by Dr Beh. First, as Asia became the key global growth engine from about 2005, EDB moved Singapore's position to the MNCs from "Host" to "Home", elevating Singapore from just a good host location for OHQs to a "Home" for both the global companies looking to invest in Asia, and Asian companies aiming to go international. The restructuring and upgrading of the manufacturing sector over the years, also enabled the sector to take on ever-rising levels of complexity in the products manufactured. The opportunity "was quite timely and [Singapore was] fabulously positioned"<sup>31</sup> to exploit it. Second, the government recognised that hard infrastructure had to be coupled with soft infrastructure in order to create a vibrant city that would enhance Singapore's liveability and keep talent rooted. As land use became more constrained, the softer aspects of a city were necessary to give Singapore a competitive edge. Third, instead of focusing just on input or capacity driven growth, there had to be more emphasis on innovation and productivity. Dr Beh summarised this as "creating value with the head (knowledge), the heart (customer experience) and the hand (skills)".

## **Infrastructure Developments: Innovating the Industrial Landscape**

As Singapore positioned its knowledge-based economy towards a greater focus on innovation from 2000, the industrial parks were correspondingly rethought to meet the more complex nature of such industrial activities. JTC recognised that the low-density nature of the earlier business parks did not make optimal use of the land and would not create a lively town and community.

JTC had launched the Industrial Land Plan for the 21st Century (IP21) in 1997, to serve as its guide for implementing the 1991 Concept Plan. The aim was to optimise land use and ensure a continued supply of affordable land to meet industrial needs. The old industrial estates were decanted for high value-add industrial purposes, for example, wafer fabrication parks. JTC also introduced new 'stack up' factories and 'ramp up' factories, which were innovative space-saving solutions. The plot ratio of factories increased from 0.5 in the 1970s, to 2.1 in the 1990s. For the near future, JTC is working to achieve a 2.5 plot ratio for its more advanced factories.

The key challenge was keeping Singapore's competitive edge in a complex and competitive global landscape while addressing land constraints. The 2001 Concept Plan (see **Appendix C**) made provisions for high value-added industries which contributed significantly to Singapore's economic growth. It instituted a new "impact-based" zoning system where non-pollutive businesses could house different uses under one roof and change activities easily without rezoning, thus creating the potential for mixed-use buildings and "work-live-learn-play" environments.<sup>32</sup> This line of thinking sparked the idea for the one-north development (See **Box Story 2**), and later, the Clean Tech Park (See **Box Story 3**) and Seletar Aerospace Park (See **Box Story 4**).

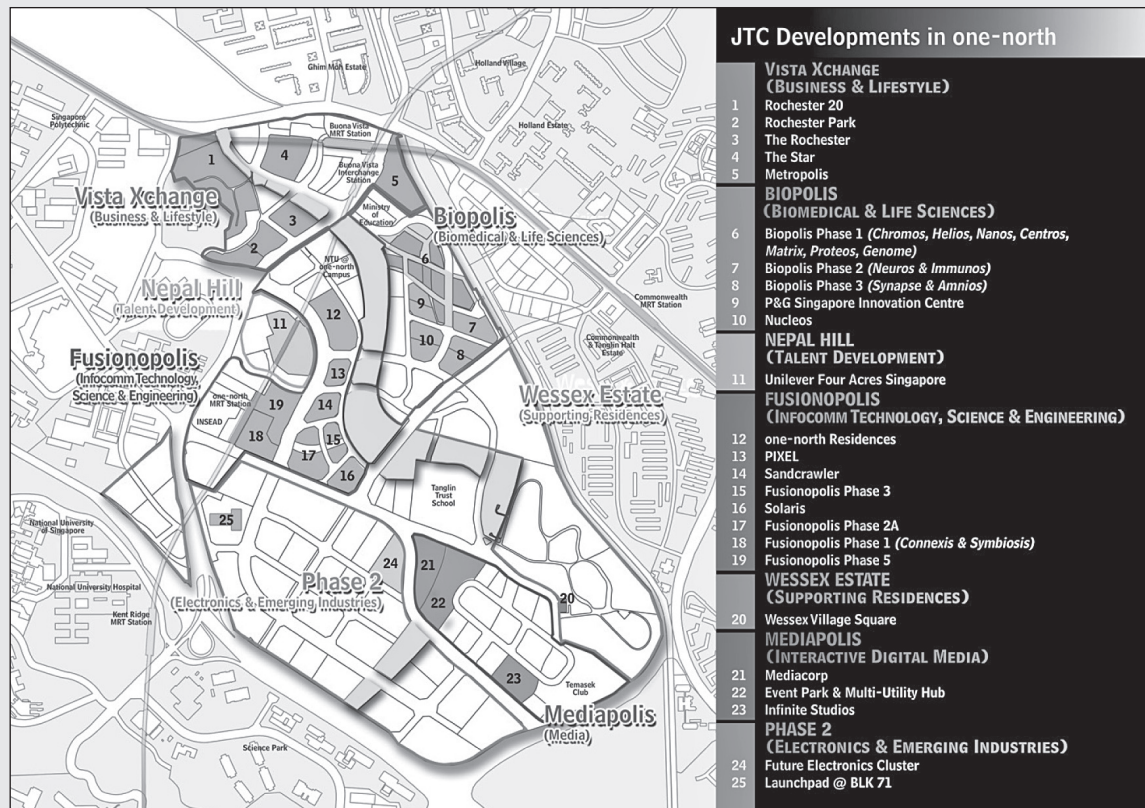
## BOX STORY 2

### SHAPING A WORK-LIVE-LEARN-PLAY KNOWLEDGE LANDSCAPE

The 200-hectare one-north development created a “city within a city” that houses cutting-edge researchers, technopreneurs and scientists.<sup>33</sup> It essentially redefined the concept of industrial parks as an ecosystem-like industrial landscape where people could work and live as a community. Its location in Buona Vista is near the National University of Singapore, Singapore Polytechnic, Johns Hopkins and INSEAD — opening up the possibility of collaboration and exchanges between the industries in one-north and these tertiary institutions.

one-north was created to support and facilitate innovation and enterprise in what the government saw as high-growth knowledge clusters, namely, BMS, life sciences, engineering, information communications and media. The master plan for one-north, unveiled in 2001, identified three distinct sections — Biopolis (a hub for BMS and life sciences), Fusionopolis (a hub for infocomm technology, science and engineering) and Mediapolis (a hub for media related industries) — that form the

FIGURE 4 Map of one-north



Source: JTC Corporation

central arteries of the dense network of social, commercial and residential nodes.<sup>34</sup> The first three phases of Biopolis were completed in 2003, 2006, and 2010. Today, Biopolis has already become a renowned enclave for R&D in BMS. The first phase for Fusionopolis was completed in 2008 while phase 2B was completed in 2010. Construction for Biopolis and Fusionopolis is still ongoing.

one-north is an innovative infrastructure solution in that the nature of the industry cluster in question has actually generated the morphology of the corresponding industrial landscape. In a sense, it is a new class of industrial infrastructure that integrates research and business development activities within a bustling township.<sup>35</sup> one-north has been conceived as a place to “work, live, learn and play”. It represents the shift from purely providing hard infrastructure to developing the soft aspects that make a place liveable. The government sees that as a competitive edge in a knowledge economy in terms of attracting global investors, but also the very mobile talent. “They not only choose where the research is, they probably want to choose a place where they can actually live and play while enjoying the work,”<sup>36</sup> explained Mr Heah Soon Poh, current Assistant CEO and Director of the Biomedical and Chemicals Cluster at JTC.

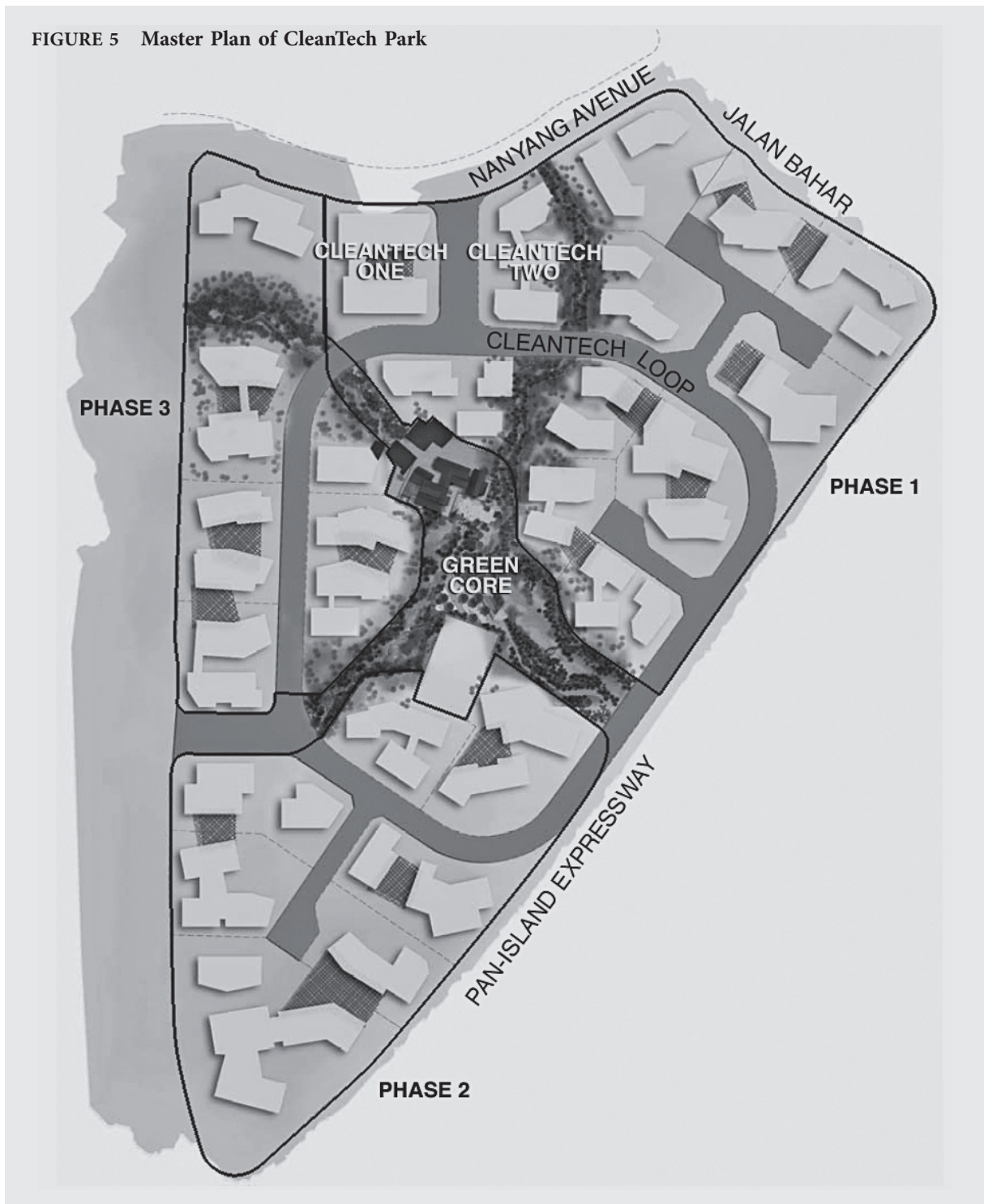
## BOX STORY 3

### A LIVING LABORATORY FOR CLEAN TECHNOLOGIES

Around 2005, EDB identified clean technology as a potential sector to add to the four big clusters of electronics, engineering, chemicals and BMS that were anchoring Singapore’s manufacturing sector.<sup>37</sup> As such, JTC began to scout for an appropriate site and chose an area beside the Nanyang Technological University in the western part of Singapore, which has a strong emphasis on R&D in clean technology and related sciences. Like one-north, the CleanTech Park seeks to create a conducive and vibrant ecosystem for the network of industries within the cluster, and to tap on collaborations between industry and academia.

The Park is envisioned to be a large-scale integrated “living laboratory” for test-bedding and showcasing clean technology system solutions. The master plan, jointly launched by EDB and JTC in February 2010, reflects the nature of the industry itself. The lush green site is designed with an ecological consciousness. Plant-covered trellises between buildings will provide shading and enhance the “walkability” between the open spaces; minimal land-cut will be carried out to conserve trees and the existing natural landscape. This highly differentiated and specialised industrial landscape is expected to support Singapore’s aim to be a globally competitive hub for the R&D and manufacturing of green technologies.

FIGURE 5 Master Plan of CleanTech Park



Source: JTC Corporation

**BOX STORY 4****AN INTEGRATED PARK FOR AEROSPACE INDUSTRIES**

The aerospace industry has been one of the fastest growing industries in Singapore since the 1990s. In 2005, EDB and JTC, with the support of the Civil Aviation Authority of Singapore (CAAS), championed the idea of developing Seletar Airport (a civilian airport in the northeast of Singapore) into an integrated aerospace park with both runway and non-runway dependent activities clustered together. A year later, the government approved the idea for the 300-hectare Seletar Aerospace Park (SAP) and JTC was appointed master planner and developer for its development.

EDB and JTC have worked closely to market SAP even as it is being developed. Global aerospace leaders including Rolls Royce, Eurocopter, Bell Helicopter, Pratt and Whitney and ST Aerospace have committed to significant projects in SAP. For example, Rolls Royce's \$700 million investment in their Seletar campus marked the single largest investment ever undertaken by the company. It will be assembling and testing engines for wide-bodied aircraft — the first time that such high-performance aircraft engines are produced in Asia. Rolls Royce will also manufacture sophisticated wide-chord fan blades at SAP. With this, SAP is well placed to develop a unique and an integrated cluster for the manufacturing of aircraft equipment.

To facilitate this, JTC developed standard factories near the site so that companies supporting Rolls Royce as well as others engaged in aerospace component manufacturing and repair can easily set up operations and maximise the synergies. Other facilities developed at SAP include the Business Aviation Complex to house companies providing supporting services and the General Aviation Centre, offering shared facilities to help companies minimise costs. When completed in 2018, SAP is expected to contribute some \$3.3 billion annually in value-add to the economy and create 10,000 aerospace-related jobs. SAP is another example of how industrial infrastructure can serve as a unique competitive advantage for growing a key industry cluster in Singapore.

As land-scarce Singapore develops and the economy grows, the space crunch will only intensify. The government has had to experiment with and test radical new industrial infrastructure typologies that minimise land use or create “more space”. The Jurong Rock Caverns is one project that pushes the conventional boundaries of industrial space and infrastructure. It is literally “groundbreaking” as it opens a different dimension of industrial land by providing oil and condensates storage space in subterranean caverns 132 metres beneath the sea off Jurong Island. Construction is already underway, and when completed in 2014, the Jurong Rock Caverns will offer a storage capacity of 1.47 million cubic metres to the petroleum and petrochemical industries. This will help save some 60 hectares of surface land.

JTC is also undertaking feasibility studies for an array of other cutting-edge industrial infrastructure solutions that will usurp conventional norms. These include very large floating structures for oil storage, an underground science city near Kent Ridge, the Offshore Marine Centre, and the cluster industrial complex with mega hoist concept. These innovative solutions on industrial land use, some already in the midst of implementation while others are still under consideration, will continue to provide Singapore’s economy the competitive edge to advance forward.

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# 4

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## Iterations Between Economic and Infrastructure Development

The main key to Singapore’s successful industrialisation experience lies in the iterations and integration between economic priorities and industrial infrastructure development. These occur in two areas — Singapore’s choice of industries over the years and in the dynamics of its institutional structures.

### 4.1 INDUSTRY DEVELOPMENT IN SINGAPORE

Based on the past 50 years, Singapore’s industrial choices — both planned and fortuitous — have allowed the economy to move upwards and outwards along the value chain. The interactions between the economic priorities and industrial infrastructure have played an important role.

Singapore’s industry development strategy over the years can be understood through the framework of “product space”. This is a theory developed by the Harvard economists, Ricardo Hausmann and Dani Rodrick, which looks at the relatedness of product lines and their relation to a country’s economic progress. Hausmann and Rodrick used the metaphor of a forest of highly unequal density — where some parts are densely packed with trees, while others are sparsely populated — to explain the product space. The different industries are like the trees in this forest, and the companies are like monkeys living on these trees. It is easier to produce better products in the same industries (moving up the same trees) or by using existing capabilities to manufacture items that are close to the original products in the product space (jumping to nearby trees).

Singapore had consistently identified and built capabilities which, using Hausmann and Rodrick’s metaphor, are in the densely packed part of the forest, enabling an existing industry to grow related product lines. This was done either through moving upstream towards higher value-added products or moving laterally towards a network of similar and related industries. With this strategy, the economy



could upgrade over the long term. “This whole story is about capability,” explained Mr Tan Choon Shian. “What is the capability you build at each stage so that that capability positions you when the next industry comes? It could be a very adjacent industry, could be a totally different industry but the capability is key.”<sup>1</sup>

The corresponding industrial infrastructure has always been developed in tandem, thus supporting the industrial strategy. This has facilitated the consistent move of Singapore’s economy up the value chain. Key industry clusters in Singapore such as electronics, precision engineering, and chemicals developed along this approach.

## **Electronics and Precision Engineering Clusters**

In the early days of industrialisation, even though Singapore welcomed any industry as it had little choice then, there was still some element of picking industries. As Dr Goh Keng Swee put it, “It would take a very obtuse economist not to have recognised that [back] in the mid-1960s, the electronics industry was in the state of dynamic expansion.”<sup>2</sup>

Singapore started with the manufacturing of semiconductors and assembly of consumer electronics like radios and TVs. What the companies required was simply abundant and cheap labour as the work was low-skilled and labour-intensive in nature. Standard factories were built to house these simple manufacturing activities. Gradually, with EDB’s promotion of the idea to create parts suppliers in Singapore, the companies realised that if they could source for the various electronic parts for assembly locally, it would save costs. Thus they were convinced, and from this grew a sector of parts suppliers.

Over time, there was a growing saturation of semiconductor plants in Singapore, which Dr Goh told EDB was not sustainable for a small economy with a small population like Singapore.<sup>3</sup> Industry in Singapore needed to move towards more skill and capital-intensive products, rather than stay at low-end assembly-based manufacturing. By the 1970s, Singapore moved towards precision engineering. Some of the parts required for electronic products needed precise tolerance in their production, for example metal moulding, watch movements and camera parts. Apart from capital, this sector required a higher level of skills. This dovetailed nicely with EDB’s training initiatives which had been rolled out intensively during that period. Unfortunately, Rollei — a leading camera company that EDB brought in to anchor the precision engineering industry — closed operations in 1981, and many skilled technicians were left jobless. But because they had already built up their competence in both mass production and the skills to engineer a variety of precise products, this combination of capabilities was easily transferable when the wave of manufacturing PCs and hard disk drives came in the 1980s.

Semiconductor production also continued to progress to the high value-added wafer fabrication from the 1990s till today. As the manufacturing processes were much more sophisticated, the corresponding industrial infrastructure also required more calibrated requirements. This was the period where the clustering strategy took off, and specialised industrial parks that housed wafer fabrication were built.

Another related industry cluster branched out from electronics as well. As the manufacture of semiconductors requires similar capabilities with that of solar panels, this eventually led EDB to the pursuit of the clean technology industry from 2005 onwards. In tandem with this move, JTC is building the CleanTech Park to house these new, innovation-intensive industries.

## Chemicals Cluster

The chemicals cluster has its roots in a significant foreign investment made in the early days — an oil refinery established by Shell on Pulau Bukom in 1961. By the late 1970s, the petroleum industry was established with four major players operating in Singapore. This provided the basis for Singapore to eventually move towards developing a petrochemicals industry which was realised when the Petrochemical Corporation of Singapore (PCS) established a petrochemical complex on Pulau Ayer Merbau in 1984.

EDB had found that globally, there was a dearth of new chemical plants due to the oil price hikes in the 1970s which dissuaded companies from making new investments. This sparked an idea to create a chemicals hub in Singapore, on a concept of “state-enabled industry integration.”<sup>4</sup> The creation of Jurong Island in the 1990s as an integrated industrial park specialised in chemicals catalysed the development of Singapore’s whole chemical cluster, which includes petroleum, petrochemicals and specialty chemicals.

The success of the chemicals cluster is intrinsically embedded in and facilitated by the innovative infrastructure. JTC and EDB are now working towards version 2.0 of Jurong Island, to raise the competitiveness of and address the sustainability of the infrastructure in the chemicals cluster.

## 4.2 RELATIONSHIP BETWEEN EDB AND JTC

The well-synchronised development of Singapore’s economy and industrial infrastructural landscape can be largely attributed to the symbiotic relationship between JTC and EDB.

Strong institutional and personal networks have been important factors in fostering a tight and effective partnership between the two agencies. Essentially, JTC was formed out of EDB and many of its top management over the years were formerly from EDB as well. As both reside under the umbrella of the Ministry of Trade and Industry, the leaders of both agencies are aligned and they share the same end goals. Moreover, both EDB and JTC are organisationally structured by industry clusters with the same teams working together on projects, strengthening the relationship over time.

*“While we have bold vision, so far we have been quite prudent and that is a sort of dynamic between EDB and JTC, because JTC has to do the sums. So it is an ongoing tension that pulls both sides slightly away but I think that gives us a better solution.”<sup>5</sup>*

*Mr Tan Choon Shian, Deputy MD of EDB*

Their roles are complementary. EDB serves as the front-line strategist and investment promoter. It identifies industries for pursuit, crafting the overall strategy for industrial and economic development. It then targets specific companies, nurturing good connections and relationships while making the sales pitch for Singapore. JTC works as the supportive home-based developer and regulator, working to prepare the industrial land and unique infrastructure solutions for the investors that EDB brings in. Today, JTC is more than just a custodian and developer of industrial land. It has evolved into an Industrial Infrastructure Innovator and a “value-creating partner” for industry.<sup>6</sup> EDB and JTC also work closely with the other economic promotion agencies such as SPRING (agency responsible for developing Singapore enterprises), the Media Development Authority (agency responsible for the media industry) and A\*STAR (agency responsible for research and development), among others.

While JTC does internally analyse the feasibility of EDB’s proposals to pursue particular industries, at the end of the day, both agencies will come together through an iterative and communicative process to see how they can make things work.<sup>7</sup> This close and mutual partnership between EDB and JTC has been the lynchpin that facilitated the remarkable transformation of Singapore’s economic and industrial infrastructure development over the last 50 years.

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# 5

## Conclusion

An integrated approach to economic direction and industrial infrastructure, strategic industry choices and close institutional ties, have marked the evolution of Singapore's economy and industrial landscape. Such an evolution has allowed Singapore's competitiveness to be embedded into the blueprints, hardware and specifications of buildings and large tracts of land.

FIGURE 6 Singapore's Economic and Industrial Infrastructure Development in Tandem

Period	Economic Objectives	Industrial Strategy	Industrial Infrastructure
1960s	Job creation through industrialisation	Labour-intensive, low-skilled industries	Creating the first industrial township (Jurong) Standard low-rise and flatted factories (generic, plug-and-play, quick start-up environment)
1970s to early 1980s	Accelerating industrialisation	Skill-intensive industries	Expansion and improvement of existing industrial estates Addition of new industrial estates Specific industrial estates designated according to industries Creation of business parks (Singapore Science Park)
late 1980s to 1990s	Shifting towards a global knowledge-based economy	Capital- and knowledge-intensive industries	More industrial parks along the technological corridors (Business Parks, Tuas Biomedical Park, etc.) Chemicals hub (Jurong Island) Industrial infrastructure developed as hubs that serve specific industry clusters
2000s	Advancing the knowledge-based economy towards innovation and enterprise	Innovation-intensive industries	Specialised industrial parks, designed as an ecosystem where the nature of the industry generates the morphology of the infrastructure (one-north, CleanTech Park) Unconventional industrial infrastructure that optimise land use or create more space (Jurong Rock Caverns, Offshore Marine Centre)

However, the challenge of continually staying relevant and competitive still remains, and it becomes even harder with a mature economy. This is especially so in a time where global uncertainty and volatility is a constant, and in the face of intense competition from the rising Asian powers of China and India. The situation is further compounded by Singapore's inherent constraints of land and labour.

With the nature of Singapore's open economy being vulnerable to the shifts in the global economy, building resilience yet exercising flexibility is vital. Essentially, Singapore will need to maintain strong economic fundamentals, as well as pursue innovation and upgrade its capabilities. "In a knowledge-based global economy, spending on education is an investment into our future," notes Mr Ngiam. "How well we do it will determine whether or not we continue to be a robust competitive economy."<sup>1</sup>

Likewise, in the development of industrial infrastructure, JTC's current efforts in innovation, experimentation and pushing the boundaries will have to continue. In so doing, Mr Manohar Khiatani, current CEO of JTC, points out that JTC has to be "very mindful about [its] developmental role" yet at the same time maintain financial discipline as a self-financing institution. The challenge is to maintain this balance, developing industrial infrastructural solutions that are financially sustainable and providing Singapore with a competitive edge in economic growth. Increasingly as well, Singapore needs to complement the hard infrastructure with the soft aspects of a global city, in order for it to remain relevant, and punch its weight above the global competition and its domestic constraints.

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# Appendices

## APPENDIX A

### KEY POLICY TIMELINE OF ECONOMIC AND INDUSTRIAL LAND & INFRASTRUCTURE DEVELOPMENT

Historical development/milestone (Economic)	Timeframe	Historical development / milestone (Infrastructure)
<b>The Winsemius Report drawn up by the UN Industrial Survey Mission, led by Dr Albert Winsemius was Singapore's industrialisation blueprint.</b>	1960	Development Plan of 1960–1964. Emphasis on infrastructure development as key to accelerate industrialisation.
<b>Economic Development Board (EDB) formed.</b>	1961	<b>Development of Jurong Industrial Estate begins.</b>
EDB switched the economic development strategy from import-substitution to export-oriented industrialisation.	1965	
<b>Economic Expansion Incentives Act — allowed foreign companies to apply for pioneer status on new investments that would get five years of tax concessions.</b>	1967	<b>Land Acquisition Act — allowed government to acquire land for public purposes like industrial infrastructure, thus enabled rapid industrial development.</b>
Employment Act — improved labour relations and investment climate.	1968	<b>Jurong Town Corporation (JTC) was formed out from EDB to take charge of industrial land and estate development and management. Through the 1960s and 1970s, JTC developed Jurong as an industrial township.</b>
	Since 1970s	New industrial estates were built in high-density residential estates to tap on available labour and for light industries; heavy and large-scale industries were located in the outlying areas.
	1971	URA's 1971 Concept Plan provided for industrial estates at the periphery of the central ring.
National Trades Union Congress (NTUC) and the National Wage Council (NWC) formed to establish a tripartite relationship between government, employers and workers, and to ensure fair wages.	1972	



Historical development/milestone (Economic)	Timeframe	Historical development / milestone (Infrastructure)
EDB established industrial skills training centres in collaboration with Tata. Centres were also established with other MNCs subsequently: Rollei (1973) and Philips (1975).		
Small Industry Finance Scheme launched to help local SMEs.	1976	
	1977	Land preparation on Pulau Ayer Merbau completed for the first Petrochemical Complex, part of Jurong Island today.
<p><b>Ministry of Trade and Industry (MTI) formed out from the Economic Development Division of the Ministry of Finance.</b></p> <p><b>Wage Correction Policy (1979–1981) — high wage increases designed to force companies to raise productivity and move towards higher value-added activities.</b></p>	1979	
“Second Industrial Revolution” launched — aimed to develop Singapore into a modern industrial economy based on science, technology, skills and knowledge. Second Economic Plan — formulated by MTI to deal with labour shortage and improve the productivity of the economy.	1980	<b>JTC drew up a 10-year master plan to prepare for new industrial landscapes and infrastructure that were conducive to attract capital and technology-intensive industries.</b>
	1981	Development of business parks, the first being Singapore Science Park I.
National Computer Board (NCB) formed. EDB established technical institutes in collaboration with foreign governments (Japan-Singapore Technical Institute, German-Singapore Institute, French-Singapore Institute).	1982	
<b>Economic Committee Report — analysed the causes of the 1985 recession and recommended new directions for the economy; new direction set for manufacturing and services as twin pillars of the economy.</b>	1985	
<p><b>Operational Headquarters (OHQ) Incentive Scheme — promoted Singapore as a strategic hub for both manufacturing and services.</b></p> <p>Local Industry Upgrading Programme (LIUP) and Small Enterprise Bureau set up to help local SMEs.</p>	1986	
Employment (Amendment) Act — implemented the flexi-wage policy announced in 1986 to create Singapore’s cost competitiveness in face of recession and regional competition for MNC investments.	1988	JTC completed the reclamation of 650 hectares of land in Tuas, one of the largest projects of its kind in the world.
SME Master Plan Report launched	1989	

Historical development/milestone (Economic)	Timeframe	Historical development / milestone (Infrastructure)
<p><b>Strategic Economic Plan (SEP) — set the strategies and programmes for Singapore to become a first league developed country within the next 30 to 40 years.</b></p> <p>National Science and Technology Board (NSTB) formed.</p> <p>National Technology Plan (1991–1995) — set out directions for the promotion of R&amp;D in Singapore</p>	1991	<p><b>URA’s 1991 Concept Plan — outlined two technological corridors, along which industrial parks for new knowledge-based industries were marked for development; identified seven offshore islands to be amalgamated through reclamation to form Jurong Island.</b></p> <p>First industrial land tender launched — up to a third of the annual supply is to be tendered out to private sector developers to establish market pricing for industrial land.</p>
<p><b>Cluster development strategy adopted to leverage on synergies between related industries — \$1 billion Cluster Development Fund (CDF) launched to catalyse the development of indigenous industries in high-growth clusters.</b></p> <p>New direction set for Singapore economy to develop an external “second wing” — agreements related to the Suzhou-Singapore Industrial Township signed; MOU on Indonesia-Malaysia-Singapore Growth Triangle (IMS-GT) signed.</p>	1993	
	1994	JTC launched new 3-storey standard factory type, which maximises land use.
	1995	Cluster development strategy executed through the development of specialised industrial parks — reclamation works for a chemicals hub on Jurong Island began; construction of wafer fabrication parks started.
National Science and Technology Plan and a \$4 billion Research & Development Fund launched to facilitate the development of science and technology in Singapore.	1996	
Committee on Singapore’s Competitiveness (CSC) formed to examine strategies to sustain our competitiveness in the medium to long term.	1997	<p><b>JTC’s Industrial Land Plan 21 (IP21) — to intensify usage of industrial land and ensure a continued supply of affordable industrial land for future needs.</b></p> <p>JTC launched new “stack-up” factories and “ramp-up” factories which maximise land use.</p>
<p>Industry 21, development blueprints for each of the manufacturing and exportable service clusters under EDB, launched.</p> <p>Infocomm Development Authority (IDA) formed from the merger of the NCB and the Telecommunication Authority of Singapore (TAS)</p>	1999	
A long-term initiative launched to develop Life Sciences as the fourth pillar of Singapore’s industries (other three are electronics, chemicals, precision engineering).	2000	Industrial Parks for the 21st Century (iPark21) initiative launched — aimed to create industrial parks that are aesthetically appealing, landscaped, integrated work-live-play environment.

Historical development/milestone (Economic)	Timeframe	Historical development / milestone (Infrastructure)
Economic Review Committee (ERC) set up by MTI.	2001	<p>URA's 2001 Concept Plan — continued to make provisions for high value-added industries which contribute significantly to Singapore's economic growth; instituted new "impact-based" zoning system where non-pollutive businesses could house different uses under one roof and change activities easily without rezoning, thus creating the potential for mixed-use buildings and work-live-learn-play environments.</p> <p>Master Plan for one-north development launched — integrated work-live-learn-play industrial landscape to serve the new knowledge-driven clusters of BMS, life sciences, infocomms, media.</p>
NSTB, TDB and PSB repositioned and renamed Agency for Science, Technology and Research (A*STAR), International Enterprise Singapore (IE Singapore) and SPRING Singapore respectively, to reflect a focus in the knowledge-driven economy.	2002	
<p><b>Economic Review Committee (ERC) Report released — set a clear direction for Singapore's economy over the next 15 years, while addressing the current downturn; key recommendations are to remake Singapore into a globalised and diversified economy, and a creative and entrepreneurial nation.</b></p> <p>Global Entrepolis initiative held by EDB to promote Singapore to investors as a global hub for talent, innovation, knowledge and business.</p> <p>Media Development Agency (MDA) formed.</p>	2003	<p>Biopolis, Singapore's first biomedical research and development facility was opened at one-north.</p> <p>JTC commenced construction of Fusionpolis, Singapore's hub for infocomm technology, science and engineering.</p>
National Science and Technology 2005 Plan launched.	2005	
National Research Foundation (NRF) formed.	2006	JTC commenced masterplanning of Seletar Aerospace Park.
	2007	JTC commenced construction of Jurong Rock Caverns — Singapore's first underground facility for oil storage, which optimises land use in an unconventional way.
EDB's "Host to Home" Roadmap — new strategy to leverage on the rise of Asia, repositioning Singapore as a Global-Asia Home for both the global companies looking to invest in Asia, and Asian companies aiming to go international; it extends Singapore's value proposition to businesses not just to help them improve their bottom line, but also to help them grow their top line.	2009	
Economic Strategies Committee (ESC) Report released – key recommendations are to achieve higher productivity growth through skills and innovation, be an energy smart economy, enhance land productivity, build a distinctive global city and endearing home.	2010	JTC and EDB unveiled master plan for CleanTech Park, Singapore's first eco-business park.

## APPENDIX B

### GOVERNANCE TOOLS OF SINGAPORE'S INDUSTRIAL INFRASTRUCTURE SYSTEM

#### (I) Legal Instruments

TOOL	DESCRIPTION
Economic Expansion Incentives Act (1967)	Allowed foreign companies to apply for pioneer status on new investments that would get five years of tax concessions.
Land Acquisition Act (1967)	Allowed government to acquire land for public purposes like industrial infrastructure, thus enabling rapid industrial development. Until the 1980s, the Jurong Town Corporation (JTC) was empowered to carry out land acquisition under the Act. This enabled JTC to move quickly and acquire land cheaply. Without these provisions, industrialisation would have been hampered.
Employment Act (1968)	Provisions improved labour relations and investment climate.
Wage Correction Policy (1979 to 1981)	A high wage policy was pursued for three years, designed to force companies to raise productivity and move towards higher value-added activities.
Employment (Amendment) Act (1988)	Implemented the flexi-wage policy announced in 1986 to improve Singapore's cost competitiveness in face of recession and regional competition for MNC investments.

#### (II) Executive Policies

TOOL	DESCRIPTION
Winsemius Report (1960)	Was drawn up by the UN Industrial Survey Mission, led by Dr Albert Winsemius, as Singapore's industrialisation blueprint.
Development Plan of 1960-1964	Gave emphasis to infrastructure development as being key to accelerate industrialisation.
1971 Concept Plan	Laid down the plans for industrial estates at the periphery of the central ring.
JTC's 10-Year Master Plan (1980)	Planned for new industrial landscapes and infrastructure that were conducive to attract capital and technology-intensive industries.
1991 Concept Plan	Outlined two technological corridors, along which industrial parks for new knowledge-based industries were marked for development; identified seven offshore islands to be amalgamated through reclamation to form Jurong Island.
Industrial Land Pricing	First tender launched in 1991 - up to a third of the annual supply to be tendered out to private sector developers to establish market pricing for industrial land.
Cluster Development Fund (CDF) (1993)	\$1 billion fund launched to catalyse the development of indigenous industries in high-growth clusters.
JTC's Industrial Land Plan 21 (IP21) (1997)	Planned for an intensified usage of industrial land and to ensure a continued supply of affordable industrial land for the future.

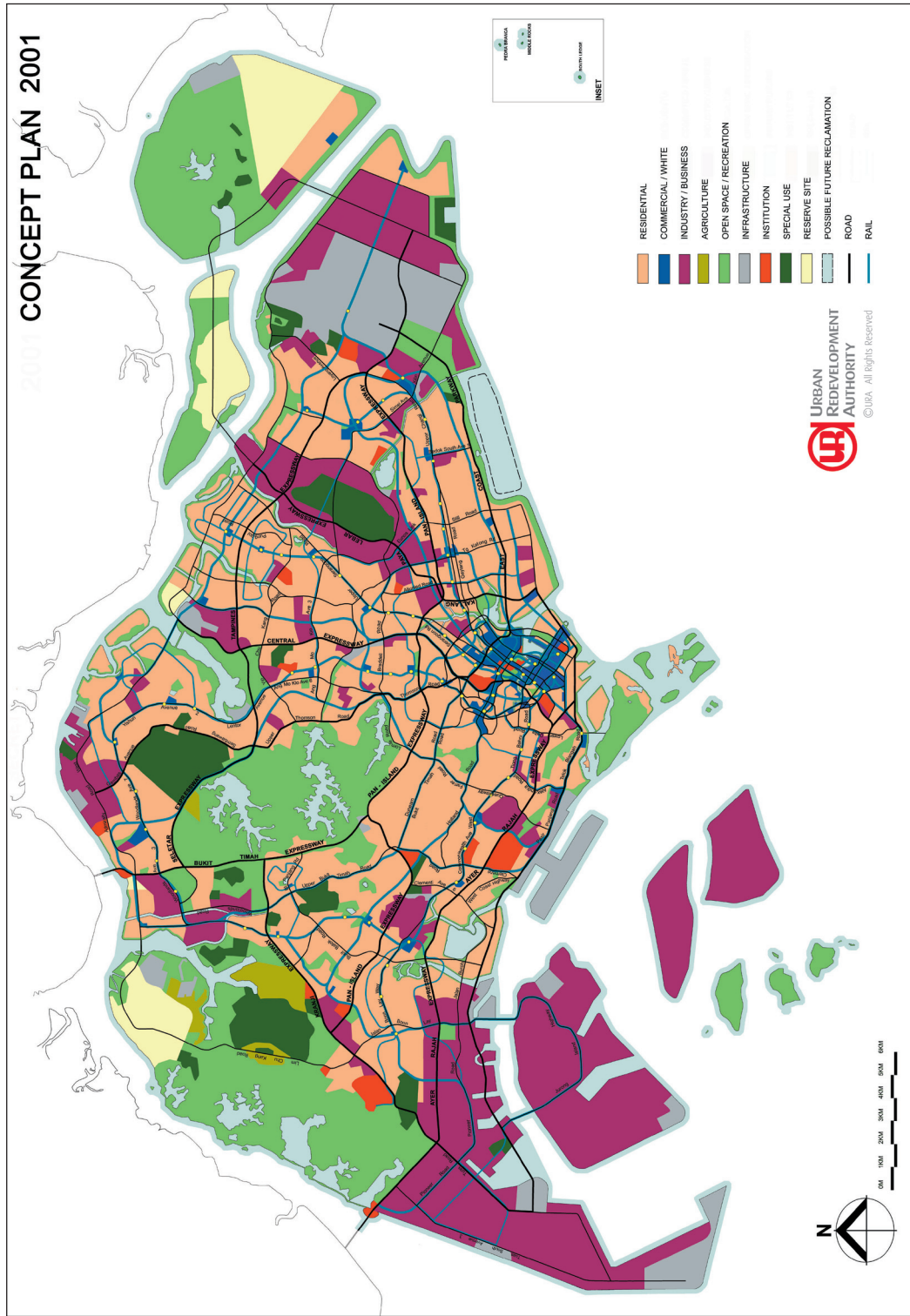
TOOL	DESCRIPTION
Industrial Parks for the 21st Century (iPark21) initiative	Creation of industrial parks that are aesthetically appealing, landscaped, integrated work-live-play environment.
2001 Concept Plan	Continued to make land and infrastructure provisions for high value-added industries which contribute significantly to Singapore's economic growth; instituted new "impact-based" zoning system where non-pollutive businesses could house different uses under one roof and change activities easily without rezoning, thus creating the potential for mixed-use buildings and work-live-learn-play environments.

### (III) Institutions

TOOL	DESCRIPTION
JTC Corporation	Plans, promotes and develops the industrial landscape for Singapore. Started out as the Jurong Town Corporation in 1968 and was renamed JTC Corporation in 2000.
Economic Development Board (EDB)	Plans and executes strategies to make Singapore a global hub for business and investment across manufacturing and internationally traded services.
Ministry of Trade and Industry (MTI)	Parent ministry of JTC and EDB. Role is to identify opportunities for growth and give broad directions for the economy.

APPENDIX C

2001 CONCEPT PLAN



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