TOWARDS TOMORROW

THE

SINGAPORE

TECHNOLOGIES

STORY

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THE SINGAPORE TECHNOLOGIES STORY

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PROLOGUE

SINGAPORE TECHNOLOGIES TODAY

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It may not be a household name, but the entity known as Singapore Technologies is behind an extraordinary range of activities in the Singapore economy. Indeed, Singapore Technologies (ST) is a microcosm of Singapore Inc.

Consider first the cutting-edge technology of wafer fabrication, the most capital intensive end of the semiconductor business. Singapore has the second largest independent foundry in the world. The company behind it – Chartered Semiconductor Manufacturing – is an arm of Singapore Technologies.

Turn next to the ancient craft of minting coins. Every cent struck in the last 30 years in Singapore has come out of the Singapore Mint – which is wholly owned by ST.

Look overhead. The A-4 Super Skyhawks and F-5E Tigers roaring above may seem like wholesale imports from the United States, but these Republic of Singapore Air Force jets have in fact been completely overhauled and souped-up by Singapore Technologies Aerospace (ST Aero). ST Aero is also involved in a joint-venture which builds the EC120, a five-seater helicopter, and has a subsidiary in Mobile, Alabama, USA, which, among other things, converts passenger planes into freighters.

Turning our eyes to the ground again, we will notice that every infantry section of the Singapore Armed Forces (SAF) is equipped with the Ultimax 100, the world's lightest machinegun. The weapon was developed by Chartered Industries of Singapore (CIS) – a wholly-owned subsidiary of Singapore Technologies.

Thousands of kilometres away, in Wuxi, China, a Singapore consortium is developing a 1,000-hectare industrial park. When completed, the ready-built factories and modern infrastructure and services in the park will provide expatriate and local workers a highly livable working environment. Leading the venture is Singapore Technologies Industrial Corporation (STIC) – ST's listed infrastructure arm.

Every day, Singaporeans make use of the world's most advanced dial-a-cab system. Users key in their customer number and a location code, and the automated system pinpoints the nearest available taxi via satellite and dispatches it. Integrating this system is the electronic arm of Singapore Technologies. Another company in the group provides an electronic monitoring system at bus depots; and yet another put in place the supervisory and control system of Singapore's Mass Rapid Transit trains.

One of the main property players in Singapore, Pidemco is the property arm of Singapore Technologies. Pidemco also has ongoing projects in Southeast Asia, China and Britain.

High-tech electronics, precision engineering, aerospace, firearms, industrial parks, tourism, telemedia, transportation, property – Singapore Technologies is even involved in advanced medical equipment. A subsidiary company, Dornier Asia Medical Systems, produces a compact lithotripter for treating kidney stones.

At last count, in 1997, Singapore Technologies employed over 21,000 people worldwide in over 200 wholly- or partially-owned subsidiaries, and was associated with

another 100 companies. The group is involved in several strategic business areas which are spread across five competencies: engineering; technology; infrastructure and lifestyle; property; and financial services.

Uniting this conglomerate is a reputation for dynamism and technology leadership, and a determination to be among the top regional players. As its mission statement states, Singapore Technologies aims to be "a technology-based multinational conglomerate, headquartered in Singapore, contributing to the development of Singapore and the region through successful enterprise." The values that guide it in this adventure are: Integrity, Value Creation, Courage, Commitment and Compassion.

A strategic and superior organisation requires a strong sense of corporate culture, involving a system of values as well as a sense of history. Just as a people without history will find themselves adrift in time, so too an organisation. An organisation must know where it has come from, in order to know where it is going. This book came about because of that desire for historical self-awareness, and to record, before it is lost to memory, the contributions and legacies of the pioneers of Singapore Technologies.

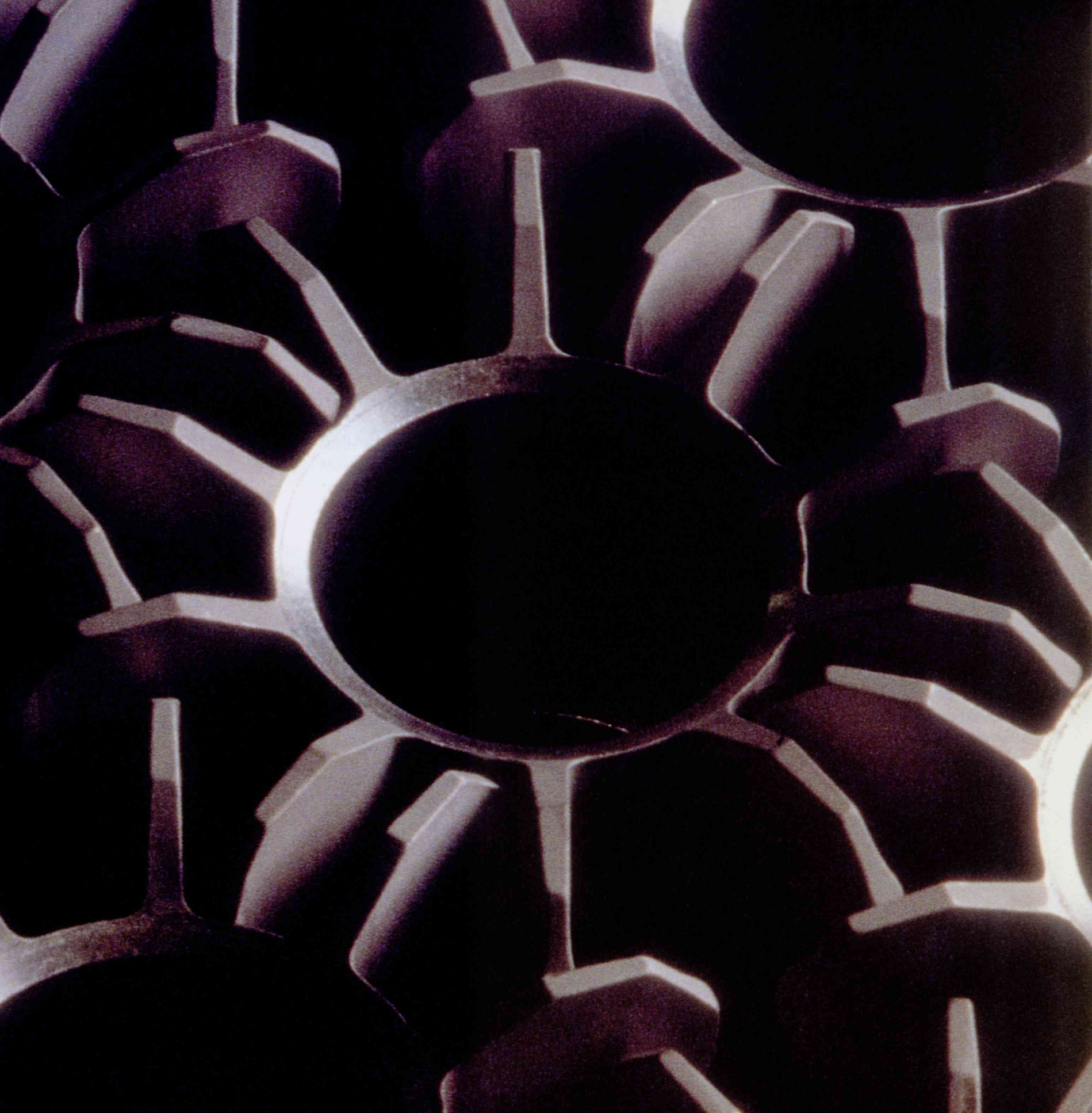
At first sight, Singapore Technologies may seem too young to qualify for a bout of serious retrospection. The name was lodged with the Registrar of Companies only in May 1990. In fact, however, the group can trace its history back to 1967, when it was founded as a munitions maker, the pioneering Chartered Industries of Singapore.

Thirty years have thus passed since its birth, a generation in human terms. From a predominantly defence group in its first decade, it grew into a broad-based industrial group by its third decade. From an infant unsure of its survival, it developed into a self-confident and altogether more worldly-wise corporation.

But despite the passage of 30 years that has altered the group virtually beyond recognition, there remain character traits in today's Singapore Technologies that can be appreciated only by looking back in time. It is impossible, for instance, to understand the corporation's fierce fighting spirit except against the backdrop of its past struggles. Its palpable mentality of being an outsider, even an underdog, makes no sense in an organisation so large until one recalls the obstacles that it faced. And only by turning back the pages of history can one grasp the special, symbiotic relationship that the group has had with the nation of Singapore.

This book records those struggles and obstacles, the successes and failures. Some of the principal actors in the story were giants on the Singapore scene, but others were private individuals who might, but should not be, forgotten. Their courage and dedication, their invention and enterprise, transformed Singapore Technologies into what it is today, and will continue to seed its future.

This history is their story.



CHAPTER ONE

AN ACT OF FAITH

The origins of Singapore Technologies are inextricably intertwined with the birth of independent Singapore. On August 9, 1965, sovereignty was thrust upon Singapore, and with sovereignty came the need to protect and defend it. The defence industries that evolved into the Singapore Technologies of today were founded as a cornerstone of national defence. ST was present at the creation of a nation.

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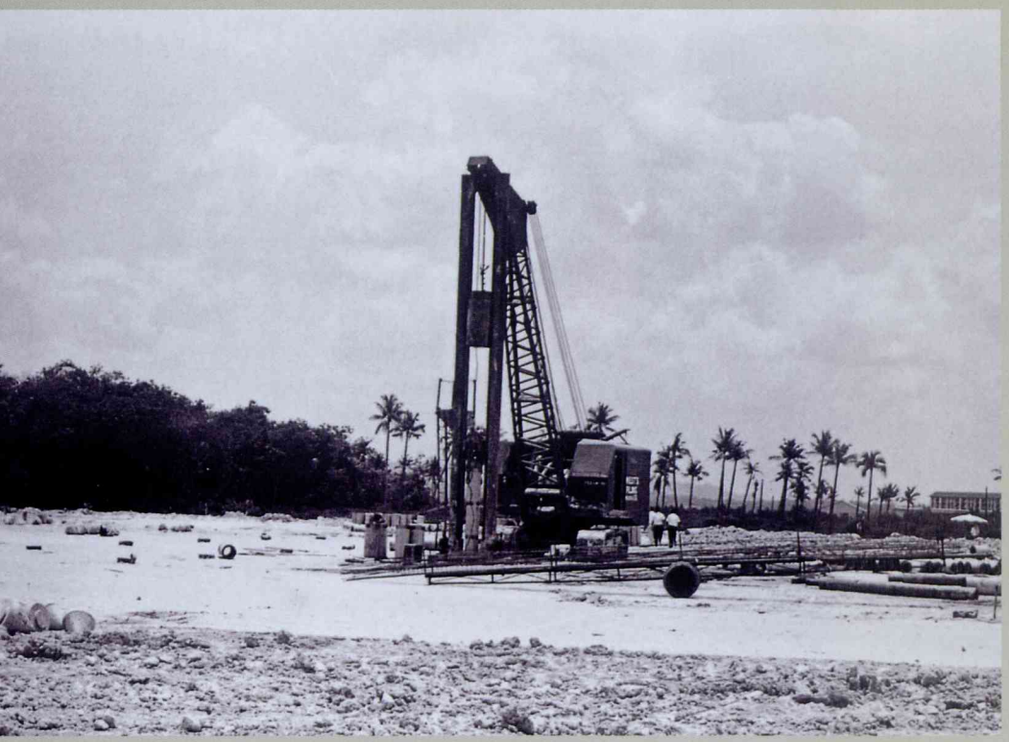


Preparing the ground: construction piling for the Chartered Industries factory at Boon Lay, 1967.

AN ACT OF FAITH

We must maintain and improve upon what we inherit.

Lee Kuan Yew

Life can only be understood backwards; but it must be lived forwards.

Sören Kierkegaard

How do we make sense of a past that is still present? How is it possible to write a history of something that has not concluded, of something that is still changing?

These may seem philosophical questions, but they are not where Singapore Technologies is concerned. The ST of today is as venturesome as it is established, as much a company with a track record as it is a company that is still trying to get off the beaten tracks.

How is it possible to say precisely what is the past of such a company? After all, it is still in the process of shaping a future for itself, a future which may well redefine its past, discovering in it possibilities which even we, from the vantage point of the present, cannot guess. In crucial respects, the past of such a company – what it was and what it is – will only be clear in the future – what it makes of itself, what it makes of its own past.

In addition to the complexities inherent in the story of ST itself, there are also the complexities which arise from the intricate links between ST and the country which nurtured it. It is difficult to draw the precise boundaries around a company which grew by helping to reshape a country which in turn reshaped the company. The story of ST is inseparable from the story of Singapore itself; the part is wrapped up with the whole.

The Ancients when faced with such a complicated tale, solved the problems of narration by beginning *in medias res*, in the midst of things. As we scan quickly in the mind's eye the succession of moments that make up the tale, what images and vignettes surface as possible windows on ST's past – and future? There are many, but a few will suffice.

There is, for instance, the seemingly improbable tale that Lai Chun Loong tells. Chun Loong, then a 27-year-old engineer in Chartered Industries of Singapore, received a call one day in 1970 from the office of Dr Goh Keng Swee, then Minister for Defence. "Bring me an M-16 assault rifle", Dr Goh growled over the telephone. Whatever does the Minister want with an assault rifle, Chun Loong wondered. Puzzled though he was, Chun Loong traipsed off immediately to Mindef, M-16 in hand. Luckily for him, the long suffering guards from the Singapore Armed Forces Provost Unit were already used to strange goings-on in the early days of the SAF, and did not pump a few well-aimed bullets into Chun Loong there and then, as he blithely raced past them, and dashed into Dr Goh's office, carrying for all the world to see a deadly weapon. "M-16, sir", said Chun Loong, as he placed the rifle, then being assembled under licence at CIS, on the Minister's table. "Strip", the Minister commanded, pointing, of course, not at Chun Loong himself, but at the weapon. After the rifle was disassembled, Dr Goh rummaged through the parts, examining closely this or that item. Then, picking up a bolt-carrier or a firing pin, he waved the item before Chun Loong, and demanded: "Why aren't we making this?"

The entire workforce of CIS, December 31, 1968.

Why not, indeed. Chun Loong got the message, and set things in motion. Soon CIS was not only assembling the Colt M-16 assault rifle, it was also making some of its components. It also began to fabricate everything from machine tools to stitchers and binders for Xerox so as to optimise CIS's core capabilities. To use the jargon of today, CIS grew by leveraging its skills, leapfrogging from one level of technology to another.

Another tale: Singapore's Changi Airport as well as its Mass Rapid Transit (MRT) train system are justly famous for their efficiency. One of the main reasons for this efficiency is their state-of-the-art 'intelligent' systems – in the case of Changi Airport, its building automation system; and in the case of the MRT, its supervisory control and communication system. The entity behind both systems is ST Electronic and Engineering (ST E&E) – a fact which should not be surprising in itself, unless one recalls the origin of the company. For it began life in 1969 in the old weapons and electronic workshops of the British Naval Base in Sembawang. Its initial task was to service and maintain the communications and electronic equipment of the SAF. It soon went on to do higher order work, like integrating the command and control systems of naval vessels. But why did such a company, a *military* electronic and engineering company no less, go into *civilian* building automation as well? Why didn't it stick to 'its own business'? Why was it also in the business of making sure that the trains ran on time?

Why not? ST E&E's 'own business' has no boundaries. The skills required to integrate the systems of naval vessels are portable, just as applicable to buildings and trains as to missile gun boats and corvettes. Why then shouldn't ST E&E service both the military and civilian worlds? Not finding any reason why it shouldn't, it did.

And finally, a tale from the recent past. The year was 1992. Many of ST's high-tech ventures, grouped together in Singapore Technologies Ventures (STV), were bleeding red. One in particular, Chartered Semiconductor Manufacturing (CSM), was doing badly. Its management, however, confident that CSM could succeed, pressed for an expansion of its capacities. If they could only increase production capacity from 9,000 wafers to 12,000 wafers a month, they reasoned, then they had a good chance to break even, and become profitable when the global electronics market picked up again. But the shareholders were doubtful. Who were these people to say that there was an upside to the market? Was it justified for a government-linked company to sink another $70 million into a venture that could not offer a guarantee of success? Should such risks be taken just because the possibility of success – *if* CSM proved successful – entailed enormous rewards, and might prove to be of strategic importance to Singapore's economy?

Why not? Nothing ventured, nothing gained. Sticking to their guns, management got their $70 million. They had announced their willingness to buy out CSM themselves,

if they did not receive the green light to expand. Their chutzpah paid off – CSM is now the world's second largest independent wafer foundry.

What is the common quality threading through all three anecdotes? It is a spirit, a quality that ST has retained through the years – a restlessness, a questing impatience, that led ST to press beyond its comfort zones virtually from the word 'go'. Why aren't we making this, Dr Goh asked, waving a firing-pin. Why shouldn't we integrate building systems as well as naval systems, someone must have asked at ST E&E. Why not expand capacities in a sunrise industry so as to better ride the crest of the next wave, the management of CSM asked.

Why? ... Why? ... Why? Every time that question was asked, the retort, without fail, was a variant of: Why not? ... Why shouldn't we? ... Why not take the risk?

Lai Chun Loong

A Colombo Plan Scholar, Lai opted in 1968 to serve out his bond as a mechanical engineer in Chartered Industries of Singapore (CIS). One of the early pioneers of the defence industry, he soldiered on at CIS beyond his bond period, becoming General Manager from 1980 to '82, Managing Director from 1983 to '89, and eventually, President from 1989 to '93. With his experience as Quality Control Manager and Works Manager, Lai was responsible for turning CIS into a maker of products of world class quality and reliability. He was also a tireless promoter of CIS products worldwide. Dr Goh credits Lai with solving the early management problems at CIS. Lai is currently the Deputy Chairman and President of Sembawang Industrial Pte Ltd.

One of the first tasks of CIS was to assemble the US Colt M-16 assault rifle. The rifle is standard issue for the SAF, as well as for many other armed forces around the world, including, of course, those of the US.

August 9, 1965. The then Prime Minister Lee Kuan Yew speaking at a historic press conference, soon after announcing the Separation of Singapore from Malaysia.

That leap of faith is what distinguishes ST. It grew by asking itself at every turn, not 'Why?', but 'Why not?' That is how an entrepreneurial company should and would respond.

But there is something else at work here, something that goes beyond entrepreneurship, something that comes from a deeper source.

'Why not?' isn't just an expression of entrepreneurial daring. It is also an expression of Will. It is an expression of the conviction that what is not yet, will be; what does not as yet exist, will come into being.

In this respect, ST is a true child of Singapore. It is not for nothing that the company answers to the name *Singapore* Technologies. Singapore too is an expression of Will. For why should an island no more than 650 square kilometres, with no natural resources, no rural hinterland, with not enough water even – why should something like this be a nation?

Why not?

"I, Lee Kuan Yew, Prime Minister of Singapore, do hereby proclaim and declare on behalf of the people and the Government of Singapore, that as of today, the 9th of August 1965, Singapore shall be forever a sovereign democratic and independent nation."

At 10 am that remarkable day, those brief words announced Singapore's independence. When Singapore separated from Malaysia less than two years after merging with it in September 1963, many wondered whether the new nation would survive. Many wondered whether independence was a prelude to a secure future, or a false dawn.

Decades later, it seems obvious that independence was not a false dawn. The island became a global city; the world became its market; and Singaporeans pulled together as one united people. But in August 1965, the future wasn't obvious. To begin with, how was the island-state going to defend itself?

"The first thing an independent state must have is a defence force", observed Dr Goh. He recalled telling Mr Lee, "You are a Prime Minister but you don't have any army." The army that Singapore did possess – all of two battalions – was two-thirds Malaysian and British.

The decision to establish the Singapore Armed Forces was taken quickly. Though some questioned the viability of a small nation like Singapore possessing an armed force, no responsible government of Singapore could have entertained such doubts. Southeast Asia was then among the most unstable regions in the world.

In addition, the British government announced in 1967 its intention to withdraw all its forces from "east of Suez", including its bases in Singapore, by 1971. The withdrawal was not only a blow to Singapore's economy – British forces contributed almost 13 percent to Singapore's GDP then – it also threatened to leave Singapore unprotected.

In 1967 the government proposed, and Parliament passed, the National Service Act. That was, and remains, one of the most important decisions Singapore ever made. Sceptics had asked after the British announced their withdrawal: 'Who will defend Singapore now?' The National Service Act gave an unambiguous answer: 'We will'.

The final shape of the SAF took a long time to establish, and is still being re-formed and reshaped to meet the requirements of the times, but the act of faith that set things in motion was made in the years between 1965 and 1970.

"Many articles and books have been published to explain how and why we succeeded", noted Mr Lee Kuan Yew in 1990, but "none have understood that our Malaysian experience forged that do-or-die attitude, which made for success. The frustrations, fears, the racial tensions, made our people determined to sacrifice everything to make Singapore succeed when we had to go it alone. Without going through that experience, not everyone would have accepted the sacrifices necessary to work together for survival."


RADIO SINGAPORE
MINISTRY OF CULTURE

SAF Pioneers touring the construction site of SAFTI at Pasir Laba: from left, the late George Edwin Bogaars, Permanent Secretary, Ministry of Interior and Defence; Dr Goh Keng Swee, Minister for Interior and Defence; Lt Col Kirpa Ram Vij, Director of SAFTI; and Mr Tan Teck Khim, Director, General Staff.

Previous Spread
Dr Goh Keng Swee speaking at the Opening Ceremony of Chartered Industries of Singapore, April 27, 1968. Seated are: second from left, Mr Howe Yoon Chong; sixth from right, Mr Whang Tar Liang; next to him, Mr Lim Kim San; fourth from right, the late Hon Sui Sen; and next to him, the late Low Guan Onn.

That is why ordinary Singaporeans responded enthusiastically when the Singapore Defence Fund was established in 1966. Charities throughout the island, in every community, suddenly found themselves short of funds, as citizens directed almost all their giving to the nation's defence. As Mr Lim Kim San, Defence Minister between 1967 and 1970, recalled in 1996, even his barber pressed him with $5 "to help Singapore buy planes".

Singaporeans, it is clear, despite the uncertainties of the times, despite the shocks, met the challenge of sovereignty at the founding moment with a magnificent faith in the future. The Singapore of today and tomorrow was summoned into existence by that faith.

And it was at this same moment of history, in 1967, that Singapore Technologies came into being. Many reasons might be cited to explain the success of ST, but one reason, above all, stands out: It was present at the creation of a nation. Like the Singapore Armed Forces and the National Service Act, Singapore Technologies too was part of that early 'do-or-die attitude'.

This origin is the single most significant factor behind ST's spirit. That spirit – the turn of mind that can say to every challenge 'Why not?' – is what it is because it was forged at the founding of Singapore.

Today, 30 years later, ST is in a position to speak of its potential for growth in a booming region; of the possibility of leveraging its skills to enter new industries; and so on. All these things came in due course, and sustain the ST of today. But in the beginning there was only faith.

The story begins with Chartered Industries of Singapore, CIS. As with so much else in Singapore in those years, from the economy to the army, CIS began humbly.

It was housed first in rented premises at Cathay Building, while the 69 acres in Jurong that the company had leased for 99 years from the Economic Development Board for $1 was being cleared and prepared. When the CIS factory in the swamplands of Jurong was completed, it was one of the earliest factories in the area.

Who would have predicted then that CIS would not only accomplish its initial aim of helping to equip the SAF, but would one day help spawn entities like Chartered Semiconductor Manufacturing?

Singapore Shipbuilding & Engineering (SSE), now known as Singapore Technologies Shipbuilding & Engineering (ST Shipbuilding), came next in 1968. It had its beginnings at the mouth of the Benoi River, constructing a boat propped up by wooden stilts on a beach that was otherwise desolate. Observers might well have laughed if they were told then that SSE would one day build missile corvettes for the Republic of Singapore Navy.

In 1969, Singapore Electronic & Engineering Ltd (SEEL), now known as ST Electronic & Engineering (ST E&E), was formed and in 1971, Singapore Automotive Engineering (SAE), now known as Singapore Technologies Automotive (ST Auto), was started to maintain SAF vehicles and tanks.

Nineteen seventy-three was a bumper year. It saw the formation of Ordnance Development & Engineering (precision engineering and production of medium calibre weapons), Allied Ordnance of Singapore (marketing and manufacture of Bofors 40mm and 57mm guns), Singapore Food Industries (to supply food to the SAF) and SAF Enterprises or SAFE (established first to sell basic food items like rice and sugar to SAF personnel, and to keep rising prices in check).

As the purposes of all the above companies make plain, ST began as a defence-related entity. By 1996, defence would constitute only 20 percent of ST's total turnover, and by the year 2000, it would be even less. But ST's defence origins not only left a mark, but also shaped the entire future course and direction of the company.

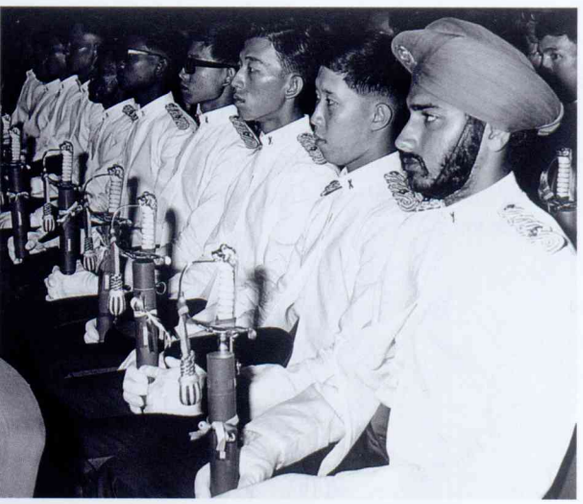
Professor Lui Pao Chuen

Professor Lui is Chief Defence Scientist, Ministry of Defence. He is also a Director of CIS, and is Adjunct Professor, Department of Industrial and Systems Engineering, National University of Singapore. After graduating with Honours from the University of Singapore in 1965, Prof Lui joined Mindef in 1966. Upon recruitment, he was commissioned a Captain in the SAF and placed in charge of setting up the Technical Department in the Logistics Division, Mindef. His association with Singapore Technologies goes back a long way to the formation of CIS.

Prof Lui recalled working on an early development project, the V-200 family of armoured vehicles. "One of the main problems was the short period of time available for development before going into production. This led to a compression in the testing programme. The first V-200 prototype sank during amphibious trials. Luckily no one got killed. Back in 1969, we had to learn by doing – and there were plenty of hard lessons to be learnt."

Sir Laurence Hartnett

The late Sir Laurence (standing next to Dr Goh) was the Quartermaster General of the Australian Army during the Second World War. When Dr Goh approached him to help set up CIS, Sir Laurence was GM of the Australian branch of General Motors. He did the initial planning for CIS's ammunition factory, and made significant innovations in the manufacture of 5.56mm rounds. Later, Sir Laurence recommended the formation of Ordnance Development & Engineering.



SAF Officer Cadets at their commissioning ceremony in 1971.

Firstly, ST's focus on technology had its start in defence-related activities. Since, of necessity, defence industries are capital-intensive and knowledge-based, they provided the technological base from which ST ventured further afield.

Secondly, because the earliest companies in the ST stable were formed to undertake ventures in areas that did not exist before in Singapore, ST became accustomed to creating new industries, and not merely extending existing capacities. The defence industries were the source of ST's entrepreneurial verve.

And thirdly, the very fact that ST was, and is, linked to a large purpose – nothing less than the safety of a people – has coloured its thinking in indefinable ways. That vital purpose constitutes an inheritance which no other company in Singapore can boast of, and will always distinguish ST from the rest.

Singapore would not have gone into defence industries if not for the requirements of security. It ought to be emphasised, though, that at no time has Singapore sought complete self-sufficiency in armaments. As Brigadier-General (NS) Lee Hsien Loong, then Second Minister for Defence (Services), explained in 1988, "because the SAF is so small, it is out of the question for us to develop all our armaments ourselves".

The strategic aim, in other words, of the local defence industry is not complete self-sufficiency, but viability. In order to be effective, the instruments of deterrence must not only appear, but must also in actuality *be,* real.

But as crucial as the defence industries were to Singapore's defence, the government did not shy away from making two crucial decisions regarding their operations which may well have been painful in the short-term, but were enormously beneficial in the long-term.

First, the defence industries were established as commercial operations, not as ordnance departments within Mindef; and second, they were required to turn a profit.

In this respect, the defence companies were treated no differently from other state-owned enterprises in Singapore – they sank or swam on the basis of their profitability. As Professor Lui Pao Chuen recalled, at the very first meeting of Sheng-Li's Board, the holding company which was to become Singapore Technologies Holdings, the discussion was all about the profitability of the various defence companies. This insistence on profitability helped keep defence costs within bounds.

No nation can survive if it allowed its military expenditure to drive it into bankruptcy. If this principle can be true of superpowers, like the former Soviet Union, it can be doubly true of small countries like Singapore. In the final analysis, the insistence on profitability added to, and did not subtract from, the strategic value of the defence industries.

But the true value of this early insistence on profitability was not to become obvious till many years later. In crucial respects, Singapore Technologies is what it is today because its pioneering defence companies began their journey on sound economic principles. The government's insistence that they be profitable ensured that they became proficient in:

- Seeking other uses for their technology and production capacities. Thus they did investment casting side-by-side with producing good-quality 5.56mm rounds.

- Leveraging their skills to enter new industries and businesses. Thus the management of large-scale industrial activities and the necessity of high-tech systems integration in the military, spawned in turn complex ventures in industrial parks and semiconductors, respectively.

- Husbanding and nurturing Singapore's technological skills. Thus the early recognition of the importance of technology in national security inculcated the more general recognition that the acquisition of knowledge, and not just capital, should be the centrepiece of ST's strategy for growth.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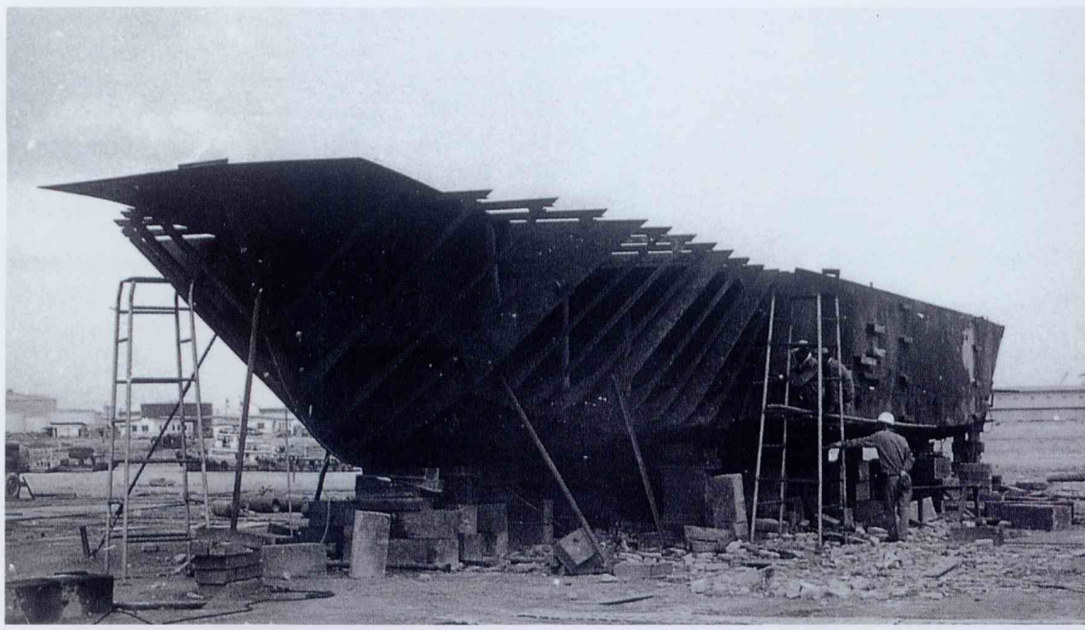
Opposite Page
The SAF Infantry marching proudly down a street, 1973.

When CIS was established in 1967, there was not much present on the island to serve as an augury of future industrial promise. When the late Albert Winsemius of the Netherlands, then Economic Advisor to the Singapore government, came to the island in the early 1960s, almost every aspect of what he saw prompted him to despair, and only one thing gave him hope – the aptitude of Singaporeans for work in manufacturing industries. He had ranked Singaporeans as among the best workers in the world.

Though the defence industries were only one among many means the new nation used to lift itself by its bootstraps, and release the energy and talents that Winsemius had spied in its people, it cannot be doubted that they played a valuable role in this regard. The defence industries were pioneers not only in military security but also of economic security.



The first vessel built by ST Shipbuilding – the "Kuala Batee", a 25m ferry boat.

The child, it is said, is the father of the man. Because this child was brought up straight, the young man is now in a position to try great things. But nobody could have known this for sure when the child was born. The pioneers had only faith that the child would turn out well. The present condition of the young man justifies their faith.

Indeed, we might even say, without being immodest, that the present proves that the origin had a touch of glory about it.

A Lion of Singapore

Dr Goh in 1959.

A journalist, doing a story on the POS Bank in 1996, found himself exclaiming to his colleagues, "goodness gracious, Dr Goh began that too".

Indeed, there is very little in modern Singapore that Dr Goh Keng Swee did not have a hand in establishing. From economic policy to monetary policy, from Defence to Education, from the Bird Park to the Singapore Symphony Orchestra, from NTUC Income to Singapore Technologies – Dr Goh was there! The sheer fertility of his mind was remarkable; his contributions to Singapore were monumental.

Dr Goh was a key member of that core team of leaders who guided Singapore through the first quarter century of its self-government and independence. Educated at Raffles College in Singapore and the London School of Economics in the UK, he possesses a PhD in Economics.

His entry into politics began in the late 1940s when he was a student in Britain. He helped found the Malayan Forum, a grouping of Malayan nationalists, together with the likes of Dr Toh Chin Chye (who later became Deputy Prime Minister of Singapore) and Tun Abdul Razak (who later became Prime Minister of Malaysia). When Dr Goh returned to Singapore, he was active in public sector unions, and helped establish the People's Action Party in 1954. He did not, however, become a full-time politician till 1959, when he left the civil service to run for elections, and became self-governing Singapore's first Minister for Finance.

He laid the ground for Singapore's industrialisation between 1959 and 1965 by establishing Jurong Industrial Estate and the Economic Development Board, among other things. When Singapore became independent in 1965, he offered himself as the first Minister for Interior and Defence. Apart from a brief return to Finance (1967-70), he remained at the helm of Defence till 1979, when he became Minister for Education and instituted far-reaching reforms of Singapore's education system. Dr Goh was also Deputy Prime Minister and First Deputy Prime Minister (1973-84), while holding various cabinet portfolios.

In 1984, he retired from politics, but not from public service. The various public offices he held after retirement included: Deputy Chairman of the Monetary Authority of Singapore (1985-92); Deputy Chairman of the Government of Singapore Investment Corporation (1981-94); Chairman of the Singapore Totalisator Board (1988-95); and Executive Chairman and Chairman of Board of Governors, Institute of East Asian Political Economy (1992-96). He has been the Economic Advisor to the State Council of the People's Republic of China on coastal development and Advisor on tourism, since 1985.

He was conferred the Ramon Magsaysay Award for Government Service in 1972, and received in 1985 the Order of Temasek (1st Class), the highest honour that the President of Singapore can bestow on a citizen.

Few men in Singapore or elsewhere have given themselves over to public service for so long, and so valuably, as Dr Goh. He is the archetypal public servant. The gods were exceedingly kind in bestowing Singapore with such a man as he.

Singapore Technologies is what it is today in no small part because Dr Goh was associated with it for most of its history. It was he who established CIS and the early defence companies. It was he who insisted that they be run on strictly commercial lines. It was he who first began pressing ST to diversify, to develop and expand its core capacities.

This account of ST's history is filled with details of Dr Goh's interventions. Even after he had stepped down as Minister for Defence, he was the person whom ST's Executive Committee Chairman Philip Yeo sought to help ST finance a computer company, and to facilitate the building of the Batam Industrial Park. Yeo described Dr Goh, even in retirement, as the "guardian angel" of the Singapore economy — the man policy makers and others went to see to bounce off ideas, to get guidance or insight, to find support and encouragement.

What follows are excerpts from an interview Dr Goh granted for this book.

On National Service and CIS

National service was the recommendation of a team of Israeli advisors. It was a small team, numbering 23 at the maximum. The head of the first team to come to Singapore was Col J Ellazari, a brilliant man who mapped out the expansion of the army, beginning with a training school, the Singapore Armed Forces Training Institute. SAFTI was to produce the core of regular officers, and subsequently was to take in each year's NS intake of non-commissioned officers and officers. Many other training institutes were also set up, each preceding the setting up of a specialised battalion, such as artillery, engineers, and the like. We were confident that the Israeli programme was workable, although we were handicapped for many years by a shortage of experienced personnel.

Regarding CIS, we had less reason to feel confident of success. The Israeli advisors had recommended a defence force far larger than what we had initially thought to be necessary. The demand for military supplies was, therefore, much higher than a few thousand rifles and ammunition.

Dr Goh, wearing the uniform of a Colonel of the Artillery Regiment, inspecting a guard of honour mounted by officer cadets of the People's Defence Force (1966). Second from the right in the honour guard is Mr Ong Pang Boon, then Minister for Education.

It was large enough to support a military industry, but how could this be done? We were confident national service would be successful, but at the beginning we were not confident about CIS.

On CIS's Beginnings

CIS was formed in 1967. Before that, I had met Sir Laurence Hartnett who was spending his last years as the Managing Director of General Motor's branch in Australia producing the Holden. He impressed me a great deal. I asked him to advise us how to create a defence industry in Singapore. Sir Laurence – Larry to his friends – knew about making cars but had no knowledge about the defence industry at first. The first product we had to make was ammunition. We required large quantities of 5.56mm rounds. To Sir Laurence, this was a challenge and he put his heart and soul into creating CIS. In fact, he liked the idea of a government company specially commissioned for the job, hence Chartered Industries. The alternative of having an arsenal, producing specially for Mindef, was never considered at anytime.

Larry Hartnett got in touch with Manurhin, an ammunition machine supplier in Mulhouse, France. And he found a new way of making ammunition. Instead of using brass sheets for making the cartridge cup, he substituted brass rods. The new method proved not only more economical but also produced better cartridge cups.

Larry Hartnett recognised that the high humidity of the tropics would hinder production. Tropical humidity would dampen the ammunition being filled into cartridges. Wanting to find out how to construct a dry room for filling operations, he visited the cold rooms in the British Naval Base and decided that this was the solution. The filling was done in a cold room.

On CIS's Growth

In 1972, with the increase in the ORBAT [Order of Battle], the time came for CIS to move from producing ammunition and minting coins to other defence products. So we engaged Sir Laurence again. He recommended that we start Ordnance Development & Engineering (ODE) to study and, if feasible, launch the manufacture of new products.

This was how we began the production of numerous defence products. We should remember three points about defence production. First, CIS had to compete with imports. Because Larry Hartnett introduced innovations in ammunition production, and because of Singapore's then low cost wages, CIS was competitive. We regularly exported ammunition to other countries. Second, the increase in the defence ORBAT meant that new products could be considered for local production on an increasing scale. And third, the rapid increase in the number of technicians and engineers turned out by our universities and polytechnics, in response to the growing demand for these types of workers, worked in favour of the rapid growth of the local defence industry.

On CIS's Early Achievements

First was the 155mm long range gun. This incorporated many new features such as in the loading of the gun. The gun outranged all existing 155mm howitzers. Next was the sub-machine gun, with a drum-fed ammunition of 100 rounds. The third was a newly designed 5.56mm rifle to take advantage of the latest discoveries.

My impression is that all these are for sale at well below current market prices for these products. One trouble with arms exports to Asian countries is that these are often financed by Western countries which usually determine the source of supplies. The arms market is heavily regulated. But in spite of this, CIS scored several remarkable successes. The ability of CIS to expand continuously in the face of limited support, a small home market, is due to its ability to compete worldwide.

On Management Problems
It was only in the first few years of CIS's existence that management problems were a major source of concern that required my intervention. But after that was solved, CIS successfully solved problems without any intervention on my part.

Larry Hartnett recruited Ronald Sng as the first General Manager. He was very effective. Unfortunately, we could only pay him civil service rates, which at that time was rather depressed. So we lost Sng and management problems became difficult under a succession of ineffective GMs.

Some were good engineers but could not run a large organisation. The problem is reduced ultimately to getting a good GM. We were fortunate in getting Philip Yeo to play a leading role. He secured the services of Lai Chun Loong, who proved a winner. It was Lai who put an end to the big problem of ineffective management at CIS.

On CIS and Singapore's Industrialisation
CIS, when it started, formed the core of the government's industrial effort. The sale of weapons and ammunition to the Singapore government formed a decreasing proportion of its total sales even though total arms sales increased considerably over the years.

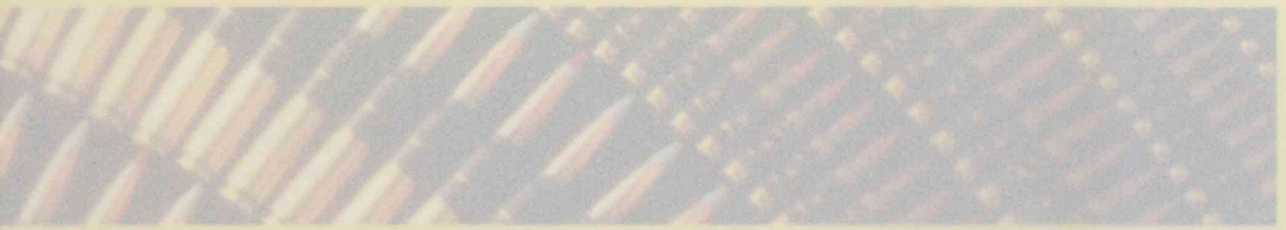
But what really promoted industrial development in Singapore was the increase in the number of technical personnel. The nurturing of the country's pool of technical personnel was something that occupied us for the best part of the last 30 years. The schools and universities adjusted gradually to the market demand for technical manpower. As the supply of such manpower grew, so did the supply of products.

Today our two universities turn out some 2,000 engineers a year, and the four polytechnics some 4,000 technical personnel. In addition, some 500 engineers receive their education abroad, mostly in the US. Even with these supplies, we have to import engineers and technical personnel from abroad, mainly China and India.

We did not use CIS as a springboard for our industrialisation programme, but it remains a centrepiece of Singapore's effort in industrialisation.

Dr Goh in 1978.

CHAPTER TWO
GROWING STRENGTH



From making ammunition for infantry rifles to building missile corvettes and upgrading fighter aircraft, Singapore's defence industries responded to the various needs of the Singapore Armed Forces, and became important components of Singapore's strategy of Total Defence. From humble beginnings, the companies steadily ascended the technology ladder, building up a reputation for quality and reliability.

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Dr Goh inspecting CIS's facilities in 1968.

GROWING STRENGTH

The first thing an independent state must have is a defence force.

Dr Goh Keng Swee

The small margin above commercial prices that the defence industries were told they could charge the SAF for the first ten years of their existence – the so-called 'incubation margin' – was to prove largely mythical, and where true, no silver spoon. The SAF was not prepared to embrace the first offerings of the novices merely on the strength of nationalistic fervour.

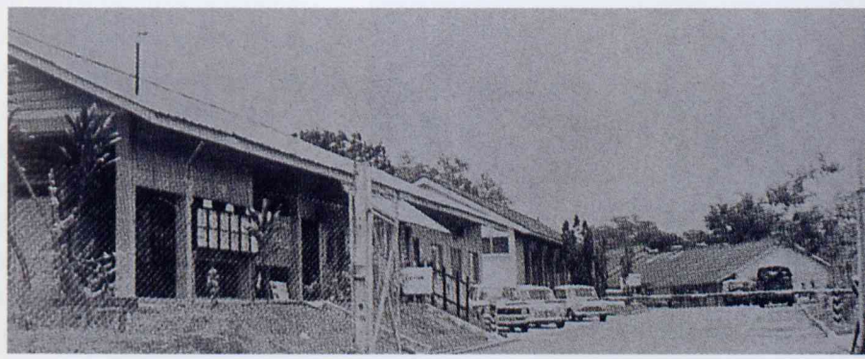
For one thing, the SAF, then largely army, had kicked off on a singularly realistic training methodology, the centre-piece of which was live firing exercises in all phases of combat and at all echelons, from the infantry section upwards. These exercises were as much a test of the ordnance as of tactical skills, and National Servicemen were not a commodity to be treated cavalierly with substandard weapons and ammunition.

Another factor was also subtly at work: the directors and non-executive chairmen of the defence companies were predominantly from the civil service, and in many cases Mindef officers. Even as they sought to make the defence industries viable, they conceded to the SAF's professional judgment on the quality of their products. Indeed, they could attest to the correctness of this judgment from direct personal experience as National Servicemen themselves not so long ago.

For these reasons, except for CIS's ammunition and the licensed production of M-16 rifles, the defence industries took a long time coming in from the cold as the major suppliers of the SAF. But a demanding SAF with the clout to reject inferior products, and the principle of commercial viability that the government had imposed on its state-owned enterprises, certainly helped concentrate minds among the management. The learning curve was both short and steep.

The defence industries were expanded as and when the growing SAF created demands of sufficient volume to warrant investments in capital and manpower to manufacture particular products.

The fourteen years from 1967 to 1980 saw the formation of the twelve core defence industries, including Singapore Food Industries and Unicorn International, the marketing arm which was to spearhead overseas sales. The most prolific years coincided with Dr Goh Keng Swee's two stints as Minister for Defence (1965-67; 70-79), but Mr Lim Kim San (67-70) and Mr Howe Yoon Chong (79-84) also provided strong impetus in their terms as Defence Ministers.



View of ST Auto's main gate in 1975. The building on the left was the main office.

Brothers in Arms: CIS & Company

Mr Tham Mow Siang, then an Administrative Assistant in the Civil Service, was tagged to do the staff study that was to blossom into the Chartered Industries of Singapore. When Tham was told of his good fortune he pleaded his ignorance, but Dr Goh told him expansively, "I will get you a consultant." When Tham asked the first Director, General Staff (as the top service chief was then known), what the ammunition requirements of the SAF over the next five years might be, Mr Tan Teck Khim told him that he had to make a reasoned estimate, since the training plans for the SAF were not in place yet. Somewhat more pungently, Tham was also told, "you *agak-agak, lah*!" (Singlish for "you guess!"). Alas, in 1966, that was the most accurate answer Tham could have got from any earthly source.

Tham duly registered the company, with its offices in Cathay Building (and later at Mt Elizabeth), while the factory was still under construction in Jurong. Meanwhile, Dr Goh asked the late Sir Laurence Hartnett to study the feasibility of manufacturing ammunition in Singapore.

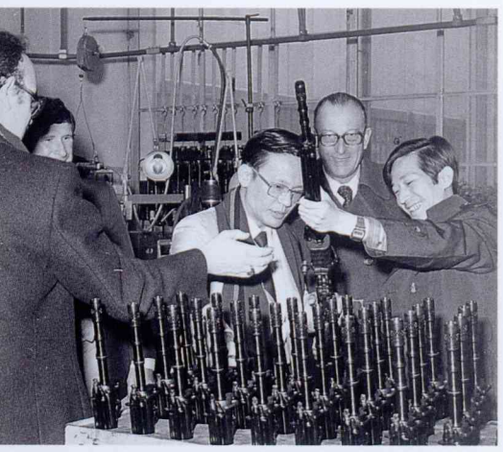
The project was codenamed "Operation Doberman". Sir Laurence, who had served as Quartermaster-General of Australia during the Second World War, zeroed in quickly on the difficulties Singapore's humidity posed to the filling of cartridges with explosives. Dr Goh, never one to let any impediment get in his way, declared his readiness to change the weather if necessary. More practically, Sir Laurence visited the British Naval Base in Singapore, and decided that the filling operation could be done in a cold room as the Royal Navy did. (Later, when CIS put in extensive air-conditioning and dehumidification units into its factory, it found that this generated dangerous levels of static electricity. Workers were forced to dress entirely in cotton and discharge static build-up on copper plates at the door of the ammunition plant's loading room.) Sir Laurence also suggested an innovative way of making the ammunition – substituting brass rods for brass sheets to make the cartridge cups.

Sir Laurence lobbied for 240 acres of swampland in Jurong for the factory, but had to settle for 69 acres. CIS has been grateful to him ever since for thinking big; by the standards of today, even 69 acres is a preposterous luxury.

The Chairman of the Singapore Manufacturers' Association, Mr Whang Tar Liang, was appointed the first Chairman of CIS, and the late George Bogaars, Permanent Secretary of the Ministry of Interior and Defence, became one of the Directors. Tham was the first Company Secretary.

Setting up the first production line proved to be easier than expected. After approaching several well-known ordnance manufacturers, CIS hit upon Manurhin of France, an ammunition machine supplier. Manurhin provided the local architects, Seow, Lee & Heah, with the technical drawings for the layout of the production line, and with a courteousness not found in many business circles today, supervised its installation. Manurhin designed the machines to ensure that CIS produced ammunition according to US military specifications.

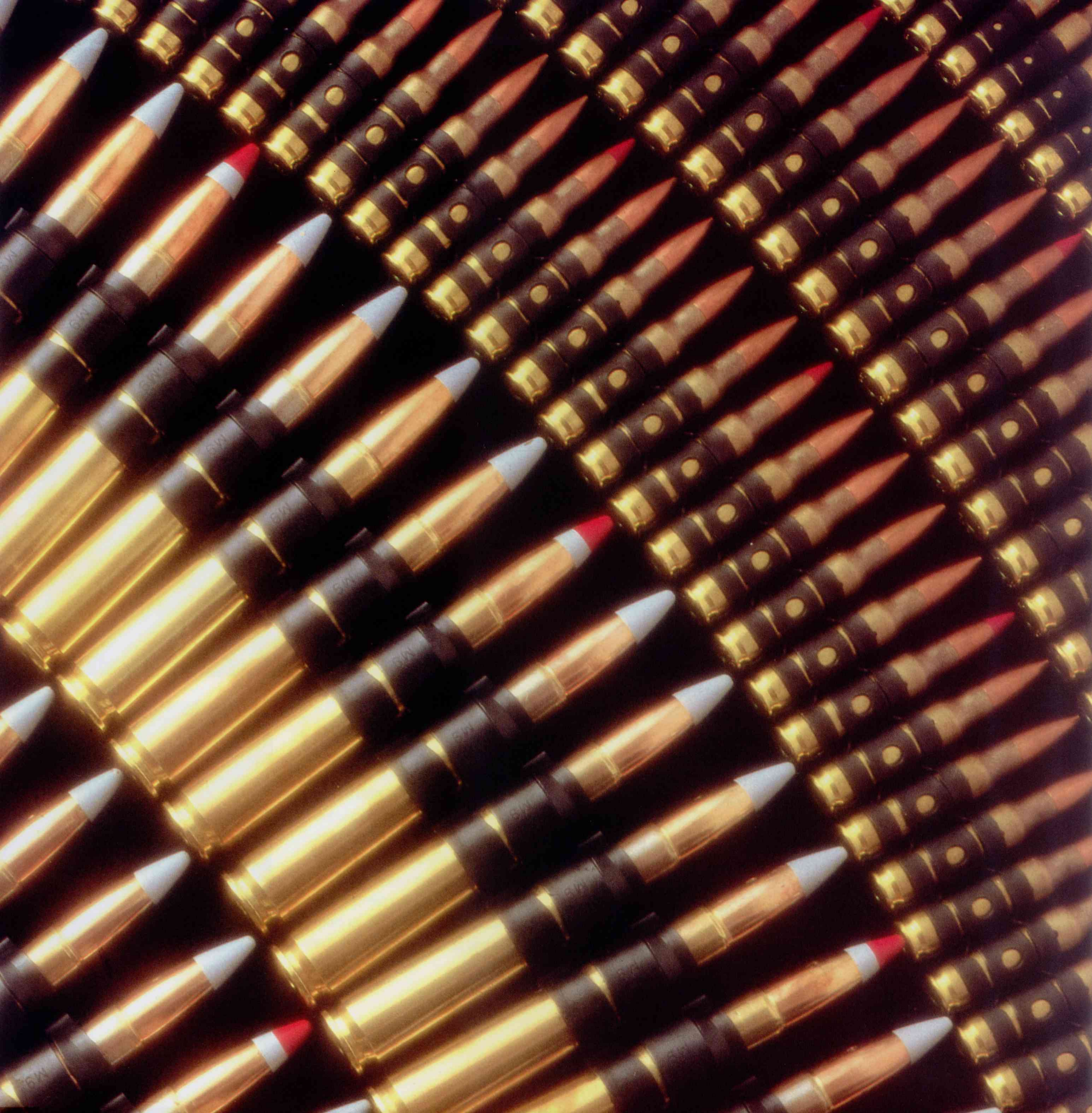
Henry Cheong (centre), Head of Engineering, CIS, and Philip Yeo (right), Chairman of CIS, visiting the Swiss Federal Arms Factory, 1981.



Mr Lai Chun Loong, another pioneer at CIS, was a returned Colombo Plan scholar in 1967. Offered a chance to work in an engineering factory, instead of the Public Works Department or the Public Utilities Board, he naturally jumped at the chance. "Any red-blooded engineer would have", he said. He and two colleagues – Mr Lawrence Lim and Mr Richard Seow – were told to report to the Central Manpower Base (CMPB) at Kallang for an interview with the General Manager of CIS. Being red-blooded engineers, they did not smell a rat. When they arrived at Kallang, they were met, not by the GM of CIS, but by the Commander of CMPB, who promptly "pre-qualified" the three of them medically fit, served them their National Service enlistment papers, and ordered them to report to the CIS office "somewhere in Jurong".

The first order of business for CIS was the production of ammunition, starting with 5.56mm rounds for the Colt M-16 assault rifle which had been adopted as the basic personal weapon of the SAF. CIS had also decided to assemble the rifle itself, following a historic deal struck by the late Ong Kah Kok – then Director of Logistics, who later became the first Chairman of Sheng-Li – with Colt Industries through the auspices of the US Department of Defence. CIS also went into the manufacture of a range of other ammunition, setting up the production lines as and when necessary, and in due course, the company diversified into a limited range of indigenous weapons developments.

CIS's ammunition production began with small calibre rounds. Over the years the company has moved up the technological ladder and now produces a wide range of ammunition, as well as explosives and pyrotechnics. Many of its products are designed in-house, and the manufacture of some products, such as large calibre rounds, involves computer-controlled machining processes and sophisticated explosives loading equipment.



Opposite Page
An array of CIS's small calibre ammunition products: 5.56mm, 7.62mm and 0.5 inch rounds.

Lai recalled with pride and satisfaction the hard grind from zinc roofed workshop to the glass and stainless steel edifices that make up the CIS conglomerate now. The pioneers literally started from scratch. With a zero base of expertise, CIS adopted the principle that every licensed production contract must include technology transfer and the appropriate training packages. Lai himself was sent to the United States and Europe to learn quality control, and became CIS's quality control manager upon his return.

But acquiring technical knowledge was not the only difficulty. There were many teething problems, one of them particularly apposite in the Singapore context – where and how to test the ammunition and guns?

Although the SAF offered the use of its ranges and live firing areas in Pasir Laba, CIS realised that this would not be practical. Daily testing of ammunition by CIS would have worn out the SAF's hospitality. CIS also had to reject the Swiss model of underground ranges among that country's many mountains, since there were no mountains in Singapore, and even if there were, underground ranges would have blown CIS's meagre budget. CIS then hit upon the novel idea of using above-ground reinforced concrete Hume sewage pipes, but a visiting team of experts from Oerlikon advised them that the enclosed environment would badly distort their results. Eventually CIS developed pocket-sized open ranges with baffling, and a procedure for bore-sighting each shot. For long-range tests, CIS made use of SAF ranges and live firing areas, or made overseas arrangements.

CIS pioneer and Chairman Mr Whang Tar Liang (left) in discussion with the late Hon Sui Sen, then Finance Minister, 1972.

The current Minister for Defence, Dr Tony Tan firing a SAR 80 rifle during a visit to CIS in 1983.

Fortunately for CIS, throughout its years in the high risk business of ammunition testing, there were remarkably few accidents. The worst case involved the explosion of a 60mm mortar round before ejection. The fault was traced to the original foreign manufacturer's fuse design. In a somewhat quirky development, CIS immediately responded by redesigning the fuse at its own initiative and expense.

From the beginning, CIS adopted two core values which have been carried through to the present in Singapore Technologies: All operations were to be technology driven, and all products were to be of an uncompromising quality. Such diligence and commitment to quality were to pay off handsomely. Not long after CIS set up shop, experts from an independent laboratory in the US, certified as 'match quality' a standard batch production of 5.56mm rounds.

An Australian Major General who served in Vietnam has testified that "if it hadn't been for the five million rounds of 5.56mm ammunition supplied by Singapore to the Australian troops in Vietnam, [the Australians] would have been in a very bad way. Moreover, the ammunition was of excellent quality and was almost the envy of the Americans. Not a single faulty round was ever revealed."

In what was to be the ultimate accolade, Switzerland, the land of precision engineering and the homebase of Oerlikon Machine Tool Works, commissioned the production of a major order of 35mm anti-aircraft ammunition. Dr Goh took a personal interest in this project.

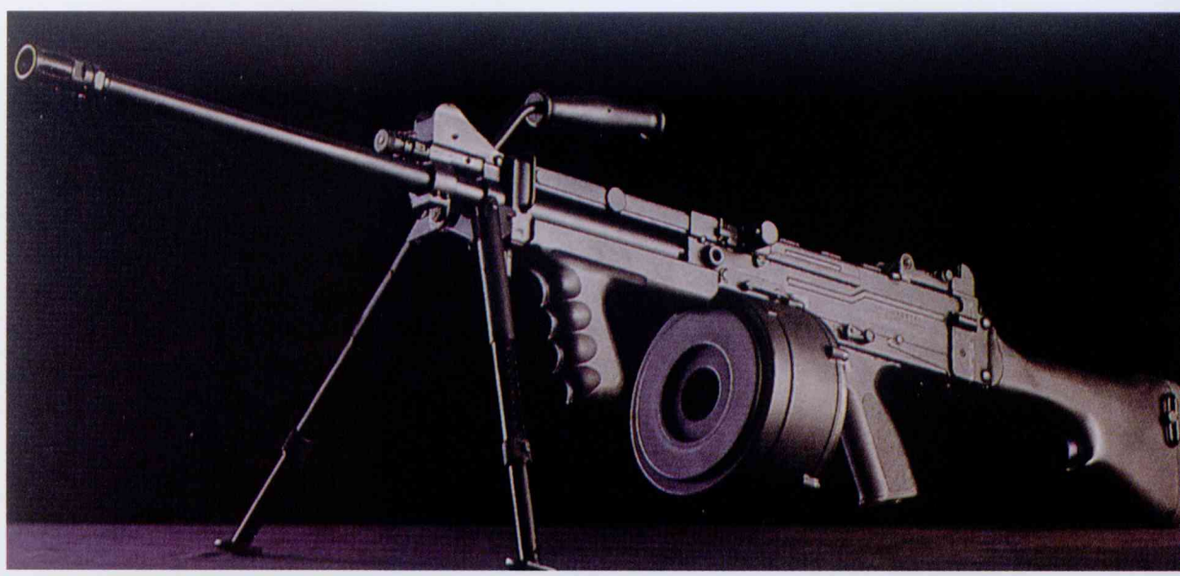
CIS spent the early years entirely licence-manufacturing and subcontracting for foreign ordnance manufacturers. In addition to the wide range of ammunition, from 5.56mm cartridges to 120mm mortar bombs, there was also the production and assembly of fuses, and the assembly and parts manufacture of M-16 rifles and grenade launchers. But CIS never had any intention of remaining only a licence-manufacturer or subcontractor. Little by little, the proportion of subassemblies increased, with the objective of eventually achieving indigenous design and production capability.

There were several abortive attempts at diversification in the early days – including a paper shredder, a computer card and a shot-gun. The first breakthrough in indigenous design was inauspicious. After fulfilling the SAF backlog of M-16 rifles – Colt Industries did not allow CIS to produce these rifles for export, other than for an 8-year limited production period – CIS embarked on the SAR 80 assault rifle. The design incorporated the best features of the then current genre of assault rifles, including a gas regulator to reduce jamming. It was only about two-thirds the price of the M-16, but good as it was, the SAF would only accept 20,000 of them, and retained the M-16 as its mainstay. This, and the fact that the evolution of the assault rifle had gone beyond the design of the SAR, undermined foreign sales of the product and eventually it was dropped.

CIS's determination to be a world-class player first saw fruit in the Ultimax 100 Section Assault Weapon. Local engineers worked with two American designers – James Sullivan and Robert Waterfield – to produce the indigenous design. Sullivan had been part of the original team responsible for the Stoner AR-15, from which the M-16 was developed. The Ultimax operated on a blowback principle, was lightweight, yet superbly controllable, used a 100-round drum magazine or the standard 30-round clip magazine, and was ideal for special operations. Using frightfully attractive women dressed in dark blue jump-suits to demonstrate the weapon, CIS left its mark at every important defence industry exhibition, and the arms industry and customers began to take notice.

Henry Cheong

With 11 years of service in the Ministry of Defence behind him, Cheong joined CIS in 1977 as the Product Development Manager. He became Director Engineering in 1983, Senior Vice President in 1991, and Executive VP in 1996. He is concurrently Director Engineering of ST, and holds directorships in several ST companies. Cheong has a BSc (Mechanical Engineering) from Queen's University, Belfast, and a MSc (Operational Research) from the US Naval Postgraduate School. Cheong is closely associated with the development of the wide range of ammunition and weapons that CIS offers.



The Ultimax, the world's lightest machinegun.

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Retrofitting the AMX-13 tank.

With the sense of arrival wrought by the Ultimax, CIS launched itself into a phase of original design and manufacture. A 0.5 inch heavy machinegun, and an automatic 40mm grenade launcher followed, among other products. At its peak CIS had about 300 engineers in the Engineering Department under Chief Engineer Mr Henry Cheong. CIS was liberal with R&D funds, but also kept one eye on the market.

The next stage of the evolution of CIS took place under the visionary leadership of Mr Philip Yeo, who in 1979 became its Executive Chairman. A systems engineer with finely honed entrepreneurial instincts, he had joined Mindef in 1969. His is a name we will come across repeatedly in the course of this history for he was the most formative influence on ST's course after the legendary Dr Goh himself. By the mid-1980s, CIS had become the star of the defence industries, and its earnings were to provide the seed capital for the diversification and expansion of the Sheng-Li group, a story that will be told in the next chapter.

Other Ordnance Players

While CIS was addressing the primary concern of making available to the SAF essential operational items needed in large quantities in peacetime and in the event of hostilities – namely, ammunition and personal weapons – other needs were making themselves felt up the logistics chain of the SAF. In the spirit of 'in for a penny, in for a pound,' Mindef plunged into commercialisation wherever possible.

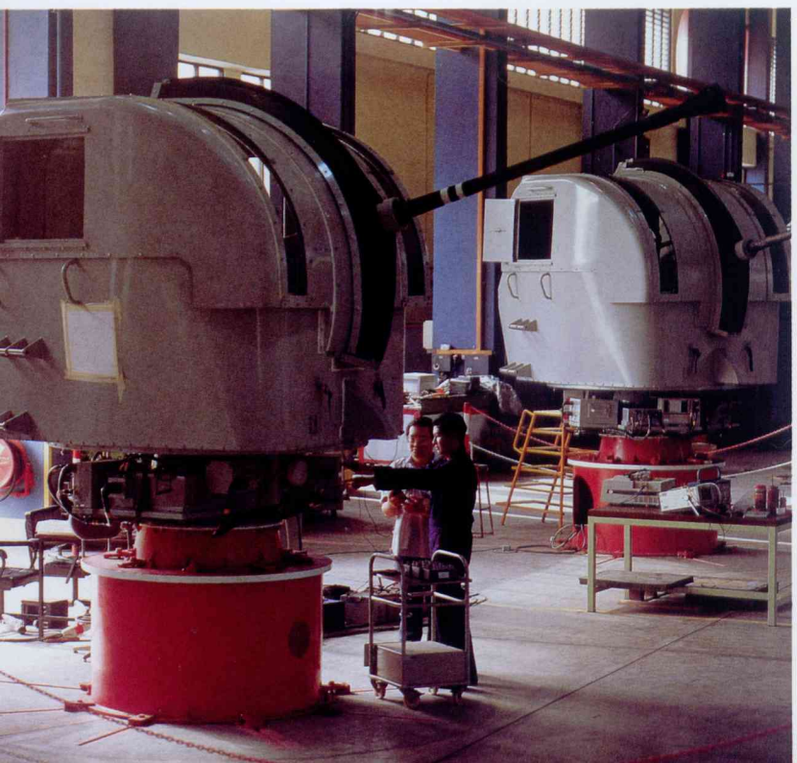
In 1971, Singapore Automotive Engineering (SAE), now known as Singapore Technologies Automotive (ST Auto), was set up in the existing vehicle maintenance base of the SAF. The initial purpose of SAE was to maintain the burgeoning vehicle fleet of the SAF – or B-vehicles as the military calls them. But SAE soon undertook the more ambitious objective of upgrading and modifying A-vehicles – in other words, those directly involved in combat, such as tanks, armoured personnel carriers, weapons systems carriers and command posts. SAE was to see many significant successes. Among them was the complete retrofitting of the AMX-13 tank with a diesel engine and an automatic transmission, which has kept the 1950s tank the mainstay of the SAF's armour corps. Other notable developments were the retrofitting of a machinegun turret to the M-113 Armoured Personnel Carrier (APC), the RBS-70 surface-to-air missile to the Cadillac Gage V-200 4X4 wheeled APC, as well as mounting the Giraffe radar system on 10-ton trucks. In 1997, ST Auto produced the first locally developed APC, the Infantry Fighting Vehicle.

Ordnance Development and Engineering (ODE) was formed in 1973, partly to fulfil the need for a company that would concentrate on small volume production of weapons like field guns which would not be needed in large numbers by the SAF, and partly because Dr Goh Keng Swee was determined to create a design engineering group for indigenous weapons development. Arguably, ODE had the most painful infancy among the defence companies as it had to struggle to learn the arcane secrets of weapons design and manufacture at a level hitherto unfamiliar to Singaporeans.

Toh Ah Kiat

Toh has worked in CIS for over 29 years. She started as a machine operator manufacturing bullets and is now a technician class 2. Toh notes that these days, because of computerisation, there are fewer workers on the factory floor than there used to be. When asked about her longevity with the company, she said, "I take it one day at a time".

Engineers testing the NADM 40L70-300 naval air defence mounts.



Mr Lim Ming Seong, once Chairman of ODE, recalled the difficulties of the early years. ODE engineers had to first acquire for themselves the basic engineering knowledge involved in manufacturing weapons before they could even dream of designing weapons themselves, he said. ODE would have had to acquire such basic knowledge even if its sole purpose had been in-country maintenance of imported weapons systems. No more than car mechanics can maintain cars without acquiring a comprehensive knowledge of existing car engines, weapons engineers have to acquire a comprehensive knowledge of existing weapons systems in order to maintain and adapt them to local operating conditions.

Despite the difficulties it faced, ODE's product line eventually included the 7.62mm General Purpose Machine Gun, the M203 40mm grenade launcher, and a whole range of mortars. ODE's biggest challenge, however, was to produce an indigenously-designed field howitzer – the FH 88, a 155mm gun. After considerable sweat, and not a few tears, ODE brought the project to fruition. The gun was unveiled in November 1988 when the Singapore Artillery received the first batch of FH 88s. The gun is now into its third generation – the FH 2000 – and it has secured export orders.

Allied Ordnance of Singapore (AOS) was established in 1973 in partnership with Bofors of Sweden to produce and market a wide variety of quick-firing weapons such as anti-aircraft and naval guns. The company also produced related munitions and fuses. In 1988 Bofors pulled out of AOS, making the company 100 percent ST-owned.

One of the most important defence companies, Unicorn International (UI), was established in 1978. While the defence industries were making breakthroughs in designing and engineering, they were making little headway in marketing their products, however superior they may have been to the competition. UI's mission was to sell the Singapore defence industries' brand name abroad. Once set-up, it carved out its own indispensable niche by taking on after-sales support and sourcing of material for the defence industries and Mindef, and the role of an agent for foreign suppliers who wished to do business with Mindef.

The FH 2000, a 52 calibre 155mm field howitzer, boasts state-of-the-art capabilities and performance, and can fire all NATO-type ammunition. Developed by ODE, the FH 2000 is the company's third generation field howitzer, based on the earlier FH 88.

Bootstrap Learning: The Story of ODE

The Ordnance Development and Engineering of Singapore (ODE) was conceived in 1973 as the nucleus of a design engineering group for indigenous weapons development.

Its significance, however, went beyond its formal aim. ODE was among the first companies to teach ST's engineering arm that it sometimes paid to jump into the deep end of the pool.

Indeed, it would be accurate to say that ODE was *thrown* into the deep end of the pool. For given Singapore's limited engineering prowess in those days, the task that Dr Goh Keng Swee set for ODE was stupendous. The indigenous weapons development he had in mind, it turned out, was nothing less than large calibre artillery.

Often referred to as the 'Queen of the battlefield', artillery is a demanding specialty. The heavy guns and its supporting paraphernalia call for big men and brute force. But the Singaporean soldier – "the bespectacled youth of slender proportions", as Dr Goh described him once, "an improbable soldier" – was neither big nor particularly brutish. Field guns systems from traditional foreign sources would have been unkind to him.

Moreover, it was already anticipated in the early 1970s that Singapore, facing a rapidly declining birth rate, could not long sustain the manning levels demanded by the guns available on the market then. From day one, therefore, Dr Goh set his sights on a locally-designed, towed 155mm field gun. He wanted something easy to deploy, with a high rate of fire and long range, and operable with a small crew.

ODE first set up shop temporarily in the CIS compound, until its own factory was ready in the same complex in 1975. Its initial assignment, however, was not a field gun but a general purpose machinegun. Producing the GPMG proved to be an excellent way of immersing ODE engineers in the design and manufacture of weapons before they began tackling the field gun project.

Mr Leo Ann Lock, now ST's Assistant Director (Systems and Technology), remembered the grind young engineers like himself faced at ODE. "There was nobody to tell us what to do. We were not dealing with general engineering but precision engineering, and that too, with the barest of facilities."

Leo and the other engineers assembled a technically sound machinegun, only to find that it stopped firing after a burst or two. "We were baffled", Leo recalled. "Mechanically, everything was in perfect order, but the gun quit nevertheless. It turned out to be a combination of many small things coming together. So we went back to the drawing board for the umpteenth time. At last we got everything right – or so we thought. The gun worked like crazy, but when we tried to switch parts – a basic requirement in battle – it conked out."

The adventure, however, had a happy ending. ODE engineers did master the intricacies of precision engineering, metallurgy and weapons design, and came out with the 7.62mm GPMG. They went on to make the M203 40mm grenade launcher, various mortars, and modified a range of towed 155mm guns that the SAF had acquired. And in 1983, a decade after

incorporation, ODE was finally ready for the *pièce de résistance*: it won a bid to produce the FH 88 for the SAF.

Mindef specifications called for a field howitzer capable of a 3-round burst in 15 seconds and a rate of fire of 6 rounds a minute, with a mechanical loader and an auxiliary motor to assist in limited manoeuvring after unlimbering the gun from the tow truck. The specifications were not significantly different from what Dr Goh had envisaged ten years earlier.

Mr Loh Chuk Yam, now President of CIS, was one of those involved in the project. Having joined ODE in 1975, he found irresistible the opportunity to pursue the original challenge set for ODE. But he almost regretted his enthusiasm. The development of the gun proved "a headache". "Things simply failed", he recalled. "We had to do a lot of test firing, and breakages dogged us. We wondered at one point if there was any light at the end of the tunnel. And the SAF wondered too if they should not have gone elsewhere."

But the persistence of the engineers paid off. A resolute fighting spirit had already been forged at ODE in the first ten years of its existence. The engineers were confident that they had matured in those years. Otherwise, ODE would not have bid for the contract.

So, true to their promise, the engineers had the prototype of the FH 88 ready within two years of the contract being awarded, and despite reverses, the production model was delivered in 1987. As BG Lee Hsien Loong noted when the 23rd Battalion of the Singapore Artillery received the gun in November 1988, "the FH 88 has undergone rigorous field tests under realistic conditions, to verify and improve the design. It has exceeded the expectations we had when we embarked on the project."

Loh attributed the success of the project to the co-operative spirit among the assembly workers, the design team, Mindef, and in particular, the gun crew that Singapore Artillery had made available to ODE for the whole project.

The FH 88 is now into its third generation – the FH 2000. It is a 52 calibre weapon with a range of 40 km, and requires a crew of eight. Its auxiliary motor provides limited self-propulsion and is capable of moving the gun at 16 kph and climbing a gradient of 45 degrees.

ODE, in the meantime, is not resting on its laurels. "We must remain relevant to the SAF", said Loh. "ODE should not be just like any other producer of guns. It must look beyond the present to the future needs of all our soldiers. National Service puts pressure on the SAF to search for customised solutions. ODE, and indeed the whole defence industry, must play an active supporting role in the SAF's efforts to build up a modern defence force."

Niccolo Machiavelli said once that fortune sometimes favours the brave. If so, ODE – which grew by taking courage and plunging into the deep end – should continue to be fortunate.

Test firing the FH 2000.

Kua Hong Pak

While serving in the Development Bank of Singapore, Kua was hand-picked by Dr Goh to be the Managing Director of Sheng-Li, and at one stage served concurrently as MD of ST Shipbuilding. Kua built up a pool of young but highly competent engineers at ST Shipbuilding and introduced a variable bonus scheme to increase productivity and encourage commitment on the part of employees. His contributions laid the foundation for ST Shipbuilding's expansion into many of its current areas of operation. Kua is now the President and CEO of Times Publishing, and also serves on the boards of Temasek Holdings and Singapore Bus Service (since 1978). An accounting graduate from the University of Singapore, he has attended Harvard Business School's Advanced Management Programme. Kua has been awarded the Public Service Medal and the Public Service Star.

The Singapore shipyard scene in the early days at Kallang River.

If CIS was a leap in the dark, Singapore Shipbuilding and Engineering (SSE), now known as Singapore Technologies Shipbuilding & Engineering (ST Shipbuilding), was a natural for an island-nation sitting at the junction of some of the busiest sea lanes in the world. Formed on the 7th of May 1968, the company represented a different dimension from CIS in the development of Singapore's defence industries because it was not conceived purely to answer the call of national security. Though Dr Goh's immediate objective in establishing it was to put in place some means for Singapore to be self-reliant in the protection of its all-important sea lanes, there is no doubt that he saw the construction of naval vessels as only one of several fields to develop in marine engineering. There was a huge civilian market for a shipyard to tap, something an ordnance factory does not have.

Accordingly, it was not Mindef which incorporated the company. Dr Goh persuaded three Singaporean entrepreneurs – Messrs Whang Tar Liang (also first Chairman of CIS), Tan Soen Swan, and Baey Lian Peck – to incorporate the company as a private venture with the Singapore Government as a minority shareholder. The yard was set up at the mouth of the Benoi River, a desolate corner of the then largely empty Jurong Industrial Estate. For the first two years, there were slim pickings and SSE subsisted by building a variety of inshore vessels for private owners. One year after incorporation, SSE records show a photograph of a forlorn-looking zinc roofed shed. SSE had 19 pairs of usually idle hands. They lacked working tools, cranes, fork lifts, reliable water supply – not to mention, public transport to and from the grim reaches of Benoi River.

Kua Hong Pak, second from left, Dr Tony Tan, second from right, and Cheong Quee Wah, right, attending an SSE ceremony in 1982.

But better days were just ahead. In 1969, the Maritime Command signed a technical cooperation agreement with Fr Lurssen Werft of West Germany which called for Lurssen to build two of six 45-metre missile gun boats at Vegesack and collaborate with SSE to build the remaining four in Singapore. This was the first step in SSE's acquisition of modern marine technology in naval strike craft construction. The next year, SSE delivered its first major vessel, the 25-metre ferry "Kuala Batee", to the Sabang Free Port Development. That same year SSE was converted into a public company. In 1973, the yard delivered the "RSS Sea Dragon", "Sea Hawk", "Sea Tiger" and "Sea Scorpion" to the Maritime Command. The weapons systems of these missile gun boats were installed by Mindef's Systems Integration Management Team.

Briefly after that, SSE's fortunes seemed secure. Despite the ongoing British withdrawal, the regional economy actually seemed to be picking up and oil exploration was in high gear. The period from 1969 to 1974 was generally a good time for Singapore shipbuilders, and SSE's turnover quadrupled from about S$64 million in 1969 to about $300 million in 1974.

Then, from out of the blue, came the formation of the Organisation of Petroleum Exporting Countries (OPEC), a global oil crisis, and a worldwide slump in the shipbuilding industry. Despite orders from the Royal Thai Navy for three 45-metre missile gun boats, from Kosan Tankers A/s of Denmark for two 1599 GRT liquefied petroleum gas tankers and from the RSN for a number of logistical vessels, SSE found itself at the start of a four year downturn.

The situation was severely aggravated by a badly underbid contract for ten multi-purpose cargo vessels for a European consortium, and a dearth of orders from the RSN, which then had a lower operational priority than the Air Force and Army. There was also persistent management and labour problems. By 1979, SSE was on the verge of financial collapse, and Sheng-Li was forced to mount a rescue operation. Mr Kua Hong Pak himself, the Managing Director of Sheng-Li then, was concurrently appointed the Managing Director of SSE.

The company embarked on a restructuring exercise, involving a fresh injection of capital that Sheng-Li obtained by pooling funds from other sister companies in the group. With the help of a team from the Navy, Kua did a first-class job raising SSE to new and higher levels of development. Within a year of his arrival, the company turned around. In 1980, SSE employees received an annual bonus for the first time.

But although RSN awarded the company another big contract in 1979 for 12 coastal patrol craft, Kua recognised that RSN's requirements in themselves would not sustain SSE. Accordingly, it began to expand into the commercial market, offering its own designs and moving aggressively into the regional market. This is a story that will be taken up again in the next chapter.

The next milestone in SSE's history came with the appointment of Philip Yeo as Chairman in 1984. As he did in CIS, Yeo introduced dramatic changes in SSE – and typically, he made the changes look easy.

The ST Shipbuilding shipyard at the mouth of Benoi River, *circa* 1990.

The 62m Missile Corvette (MCV) is specially designed for a variety of missions: escort of shipping; search and destroy of hostile surface and submarine forces; gunfire support; and general patrolling, surveillance and protection of offshore resources. The MCV, based on a well proven hull design, is highly manoeuvrable and capable of carrying a wide array of the latest weapons systems, including medium and/or long range missiles, torpedoes, a medium calibre gun, advanced radar, sonar and command and control systems.

First on Yeo's agenda was the globalisation of SSE to serve overseas customers. Then SSE acquired a CAD/CAM system (Computer-Aided-Design and Computer-Aided-Manufacturing) that enabled its design teams to produce three-dimensional designs and drafts of vessels, the first Asian shipyard to do so. The CAD/CAM put an end to the cumbersome manual drawing process, telescoped the different stages from conception to engineering design, and enabled more detailed analyses of all the issues involved in construction, including costs. It also made available to engineers a greater number of options and possible modifications while construction was proceeding.

By 1986, a benchmark 1,000 vessels had been built, repaired or refitted at Benoi. SSE's customers included the Royal Thai Navy, the Indian Coast Guard, the Royal Brunei Police Force and the US Navy. Also in 1986, SSE won another contract involving Lurssen Werft under which the first of six 62-metre missile corvettes would be built in Germany and the remaining five in Singapore. In 1993, SSE won the contract to design and build twelve 55-metre patrol vessels for the RSN. Possessing now an in-house weapons systems integration capability, SSE was more than up to the challenge of delivering ships equipped with state-of-the-art anti-submarine and anti-air suites, electronic warfare systems, as well as Harpoon surface-to-surface missiles.

The same year saw the yard move into a new area with the 3-tonne hovercraft. It was as though a well-spring of potential had suddenly begun to gush. The following years saw progress in leaps and bounds: a design for a 36m diving support vessel for the RSN; feeder container vessels for Neptune Orient Lines; and a high speed catamaran ferry for a Hong Kong-based Chinese ferry company. SSE also won an international competition against yards in Europe, USA and Japan for two RoRo/ LoLo vessels in 1991. A contract that same year for outfitting work on three mine countermeasure vessels for the RSN added glass reinforced plastic (GRP) know how to the yard. A joint-venture with Horiguchi Engineering Co Ltd was established in Indonesia in 1991. Also in 1991, SSE became the first shipyard outside Western Europe to be awarded an ISO 9001 Certificate by Lloyd's Register Quality Assurance, an industry-wide stamp of quality management.

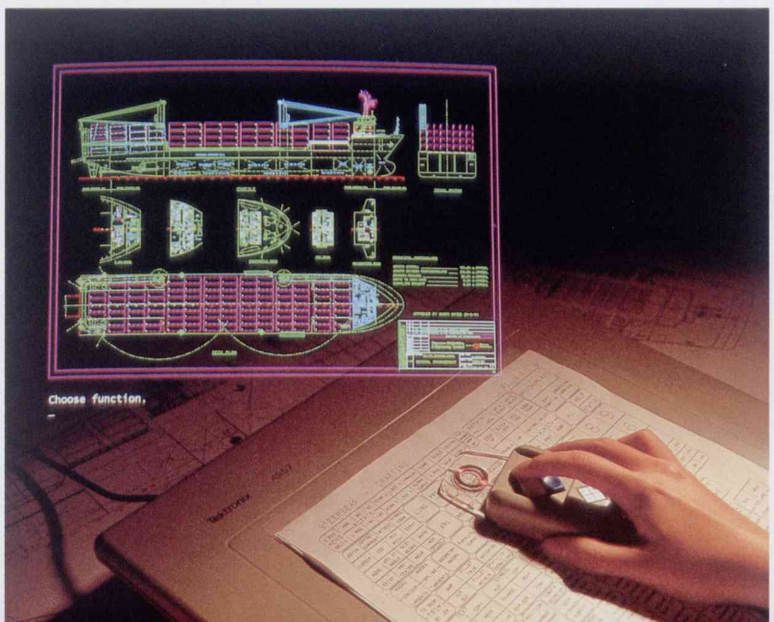
SSE's confidence in the future was demonstrated in 1995 by the construction of a second yard located at Tuas. The Tuas yard has two floating docks to build ships up to 30,000 DWT and repair ships up to 70,000 DWT respectively, complementing the 8,000 DWT one at Benoi.

Since the dog days of the late 1970s, SSE has learned to take a long-term view of the future. One of the deeper insights adversity taught it was to invest in its people. Nearly every supervisor and technician has received some degree of formal training, either locally or overseas.

Informality guides everyday interaction, and improvements are encouraged from the ground up and facilitated. A share ownership scheme has led to unprecedented productivity growth and a strong sense of commitment to quality – 'on time, every time!'

From 1968 to the present, SSE has built more than 70 vessels for Mindef and the Police Coast Guard (formerly, the Marine Police), and several for the naval and paramilitary forces of other countries. While building defence-related vessels will remain a mainstay of the yard, the company has moved swiftly to build on its capabilities in design, project management, weapons systems integration, logistics support and other engineering consultation services. In short, SSE is not just selling ships anymore. Also on the way are land-based engineering products and services, including environmental engineering projects in areas such as sewage and waste treatment, and the production of potable water. Using its accumulated experience over three dramatic decades, SSE is developing new areas of business in the shape of technology transfers, strategic alliances, direct investments, joint-ventures, diversifications, and the development of new products.

SSE – now proudly ST Shipbuilding – is one of the earliest examples among ST's defence industries of how the 'business of defence' can be both business as well as defence.



There are many advantages to Computer-Aided-Design/ Computer-Aided-Manufacture. Among them, CAD/CAM allows engineers to make detailed analyses of every aspect of design and construction without having to do extensive mechanical tests with mockup models.

Boon Swan Foo

Boon joined ST Shipbuilding as an engineer in 1979, and has held several senior management positions in the company through the years, serving as CEO from 1990 to '95. A graduate with Honours in Naval Architecture, Newcastle, UK, Boon also holds an MBA, is a Certified Chartered Accountant, and has completed Harvard Business School's Advanced Management Programme. Boon is currently President and CEO of ST Aero, and concurrently Chief Financial Officer of ST. He has been, since 1992, a Director of ST Shipbuilding and since 1996, a Director of Pidemco Land.

Boon recalled an anecdote from the days when ST Shipbuilding was fighting for its survival: "When Mr Kua joined us in the US for the negotiations for three container vessels for Hellenic Lines in 1981, first, he made us share rooms, then he told us to go and buy Chinese take-away – because it's cheaper and saves service charge. I also had to endure the snoring of one of my colleagues."

Ahmad Jaffar

Ahmad was only 17 when he joined ST Shipbuilding in 1970. Since then he has worked his way up to the position of Supervisor, Mechanical Department. Ahmad likes mixing around with the men, and makes himself available to them if they have any problems. "I was once a worker myself, and I haven't forgotten that." Describing his work, Ahmad said he enjoys what he does "because it requires skill and precision – attaching propellers to shafts, making sure components are aligned, being able to read blueprints – and I feel like an important part of every vessel that's completed."

Tan Tien Kwei

It is difficult for each of the departments working on a shipbuilding project to have a sense of the 'whole picture'. Tan, previously a project engineer, was responsible for coordinating entire projects, from the beginning when schedules are worked out and prices are estimated, to the end when the ship is delivered. "As a project engineer", Tan said, "you are not only required to make good engineering judgments, you are also required to be a good manager. It has been proven that if we all co-operate and work as a team, the job will be done." Tan is currently serving in the Design Division as Manager (Hull) of the Technical Office, where he is involved in a project for the RSN.

NS: The 14th Century Way

Feeling a little miffed that you have to do reservist training? Champing at the bit because it is months yet to ORD (Operationally Ready Date)?

After thirty years of National Service, we have all become willing to accept it as part and parcel of our rights as citizens. Still, it is only natural that we complain occasionally – shame-faced and under our breath, perhaps, but complain all the same – every time an in-camp training or an IPPT (Individual Physical Proficiency Test) rolls around. We are only human.

But the next time you feel inclined to complain, pause a little and remember this: Compared to the subjects of King Edward III of England in 1363, we not only have it good, we are in clover.

In that year, more than 630 years ago, the good King Edward sent the following message to all the Sheriffs of merry ol' England: "Whereas the people of our realm, nobles as well as commons, usually practised in their games the art of archery leading to honour and profit for the realm ... and [as a result] we gained not a little help in our wars ... now the art is almost totally neglected and the people amuse themselves with dishonest games so that the kingdom, in short, becomes truly destitute of archers."

Worried that his people would not be able to shoot straight in wartime for lack of practice in peacetime, the King enjoined his Sheriffs to make sure that the people – nobles as well as commoners – practised archery on feast days and holidays. And to make sure they did just that, and not make merry, he banned the playing of football and golf (those "dishonest games") till all Englishmen became skilled archers again.

Imagine that – marksmanship and IPPT, not just once a year, but every holiday, including Chinese New Year and Hari Raya Puasa! Kiss your long weekends goodbye, friend. And no football, golf, squash, windsurfing, tennis or karaoke, till you make perfect scores! Still feel inclined to complain, Singaporean?

King Edward's command – 'no more kicking of balls or putting on the greens for you, John Bull; from now on its just bows and arrows till you can shoot straight' – that killjoy command was what won the Battle of Agincourt 50 years later. If the Battle of Waterloo, as the saying goes, was won on the playing fields of Eton, then the Battle of Agincourt was won in the village commons of England. The poor country yokels of 14th century England, however, did not have as much fun as did the public school boys of the 19th century. At least the latter were allowed to play cricket and football while preparing to fight Napoleon; the former were restricted to target practice only.

But was King Edward just being *kiasu*? Was it really necessary to ban football and golf? We don't know. We only know that the King had good reason to be worried about his pool of skilled archers. What was at issue was not just the English propensity for "dishonest games", but their familiarity with the technology of warfare.

The longbow had already replaced the shortbow (or Welsh bow) when King Edward issued his draconian decree. Not only was the longbow's range greater than the shortbow's, it was also superior to the crossbow, the weapon of choice among the traditional enemy of the English, the French.

The crossbow was an elegant mechanical contraption, but it was fussy. The bow was attached to a stock with a groove into which the arrow had to be fitted, cocked, and held in place till released by a trigger mechanism. In the time it took to do that, a skilled longbow archer could have fired at least two arrows. All he had to do was attach the arrow to a taut string, pull string, aim, and let go. But there was a catch – the longbow placed an especial premium on skilled archery. Its great range and speed were useless advantages if English archers couldn't shoot straight. Thus, King Edward's worry; thus, the necessity of constant practice; and thus, the banning of everything that distracted from archery.

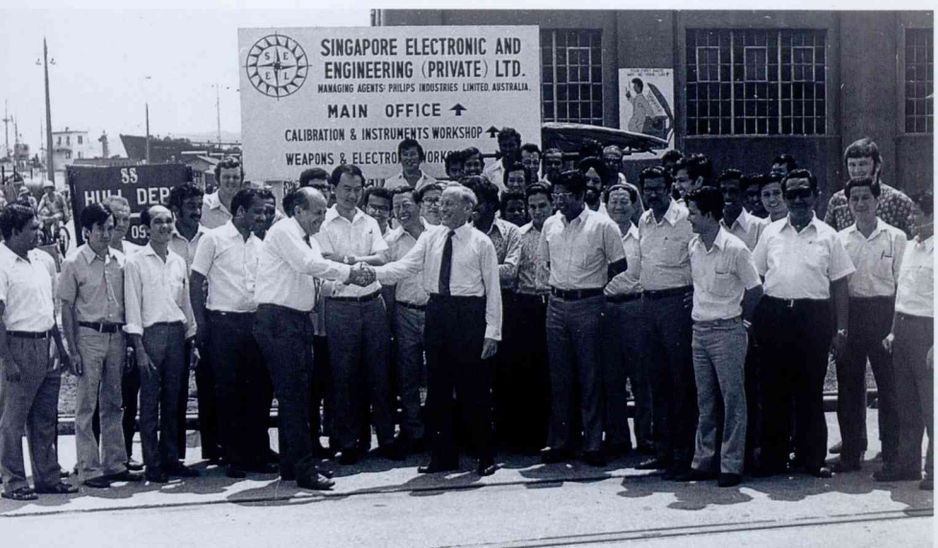
Six hundred and thirty years later – and despite the growth in sophistication of weaponry beyond anything *kiasu* King Edward could have imagined – the principle remains the same: Weaponry can be as sophisticated as the ingenuity of engineers can make them, but ordinary human beings, you and I, have to use them; and we can't if we don't know how to, if we lack the intellectual and physical wherewithal to operate the weaponry. Ultimax or the FH 88 gun, Gabriel missiles or hand-held grenade launchers – these are all well and good, and Singaporeans should be pleased we have them. But these weapons don't operate by themselves, anymore than longbows do.

So learn and practise; practise and then learn some more. And be grateful that in-camp training still leaves you enough time to play football and golf.

An archer practising with the crossbow. While the crossbow may seem a more mechanically elegant contraption than the longbow, it was the latter which proved to be a superior weapon in the Battle of Agincourt, where the English triumphed over the French.

Cheong Quee Wah

Cheong, a Colombo Plan Scholar, joined Mindef in 1971, and became Permanent Secretary of the Ministry in 1977. While in Mindef, Cheong also served, at various times, as Chairman of ST Shipbuilding and SEEL (now ST E&E), as well as ST Aerospace Engineering (formerly SAMCO) and Sheng-Li (now Singapore Technologies Holdings). His support of the defence industries from the Mindef side was crucial in seeing them through the formative years. He left Mindef in 1981 to become the Permanent Secretary of Home Affairs, then of Environment and, from 1989 to '92, concurrently of Law. Cheong has been a Fellow of the Institution of Engineers, Singapore, since 1986, and has a BSc (Mechanical Engineering) from the University of New Brunswick, a diploma in Business Administration and an MSc (Systems Engineering) from the University of Singapore. He is now the Executive Director of Sembawang Corporation.



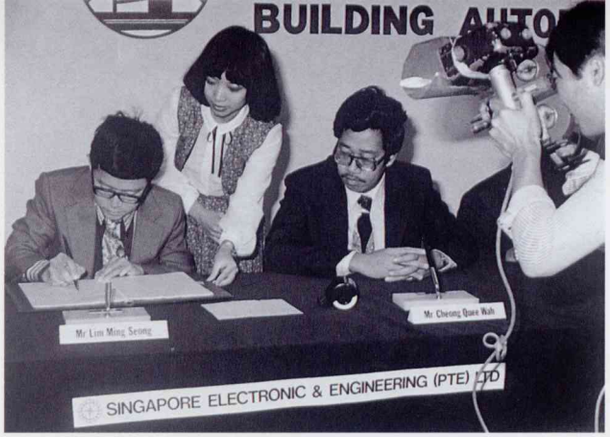
A changing of the guard: Mr Middleton (left) from Philips Australia, hands over the management of SEEL to Mr Middeldorp, from Philips Holland, in August 1974.

Riding Invisible Waves, SEEL Style

Singapore Electronic and Engineering Ltd (SEEL), now known as ST Electronic & Engineering (ST E&E), first saw the light of day on the 23rd of February 1969. The media hype surrounding the signing ceremony between the late Hon Sui Sen, then Singapore's Minister for Finance, and A J W Van Agt, Chairman of Philips Australia (who were to be the managing agents) obscured an interesting bit of trivia. The new incumbents of HM Sembawang Dockyards, Swan Hunter, had hived off the Royal Navy's old weapons and electronic workshops, judging them commercially non-viable. It was these workshops which became SEEL. Swan Hunter's judgment as to their commercial viability was to haunt Mindef's third industrial venture.

SEEL was configured differently from CIS and SSE. Its workshops were already in operation and staffed with seconded civilian and Royal Navy personnel when SEEL was incorporated. The seconded personnel were experts in weapons, electronics, calibration and electrical specialties. The workshops they worked in had long played an important role in servicing and maintaining the Royal Navy fleet (RN). It was envisaged in 1969 that the RN would continue to be SEEL's main customer until the British withdrew in 1971; and beyond that, it was hoped that US forces in Vietnam and the SAF would fill the void.

Philips Australia appointed Mr K A Middleton as Managing Director. SEEL sailed almost immediately into problems. The impact of the British pullout was more dramatic than expected, and US Navy business was not nearly enough to replace the loss of British business. Moreover, Middleton had adopted an Australian accounting system and created



SEEL GM Lim Ming Seong, and Chairman Cheong Quee Wah, at the Contract Signing Ceremony for the Building Automation System project at Changi International Airport, 1978.

a share premium account which he expected to write off, a procedure which requires a court order in Singapore. The upshot was that SEEL had no assets, but was required to meet a depreciation charge every year. Despite this inauspicious start, Middleton did effect a sound step when he initiated an aviation electronics service. As fate would have it, this fortuitous step was to divert SEEL almost completely out of its naval origins, and into the world of aviation.

Effectively, two divisions emerged at this point – Aviation and General Engineering. While the original electronics, mechanical, machine and gun workshops remained at the Naval Base, the avionics facility moved to Seletar in November 1970, and an aircraft instrument overhaul facility was established in Sembawang in May 1973. Seletar provided both hangar and workshop services for all types of aircraft communications and navigation equipment; while Sembawang's instrument overhaul facility repaired and overhauled aircraft instruments. SEEL's calibration laboratory was also updated to meet the electronic calibration needs of the SAF. Business came from private, charter and military sources. SEEL, however, remained a subsistence level operation.

Things turned bleak when US forces withdrew from Vietnam in 1973. Mindef business was still minuscule. After 20 of SEEL's staff were retrenched, and some of its assets were sold in 1974, Dr Goh seriously contemplated closing down the company, but eventually opted for a change of management. Mr H J Middeldorp, from Philips Holland, took over as Managing Director.

Recognising that Mindef business would be too little, too late, Middeldorp diversified into the distribution and servicing of various electronic products. The diversification helped to buy some time and was proven useful later when SEEL moved into the systems integration business, but the company was by no means on the mend yet.

The second management contract with Philips ran out in February 1976 – perhaps none too soon, for a major expense of SEEL in those years was the remuneration and perks of the Managing Director. In November 1975, Mindef seconded Mr Lim Ming Seong, then the Project Director of the Missile Gun Boat Project, as General Manager.

Lim walked into a company with rock-bottom morale and awash in red ink and unpaid receivables. Its strong union of workers was seething with resentment at the retrenchments. To put it mildly, the 27-year-old Colombo Plan scholar turned GM faced a daunting prospect. His only safety line was that his former boss in Mindef, Mr Cheong Quee Wah, was also Chairman of SEEL. Lim was to perform a sterling job turning things round.

He started by winning over the late Peter Vincent, then President of the Singapore Electronic & Engineering Company Employees Union (SEECEU). He placed his cards on the table and formed a union-management partnership that endures till today. Lim was a hands-on CEO who personally negotiated contracts, cultivated a sense of co-ownership as well as responsibility among the staff, and went around personally collecting outstanding debts. Within a short time, he forged a strong spirit in SEEL.

ST E&E's activities include the systems integration of ships such as the 55m Patrol Vessel.

By 1977, with a growing SAF providing more business by way of servicing contracts for electronic equipment – like aircraft simulators, radars and aircraft black boxes – and the aerospace industry taking root in Singapore, SEEL had turned profitable. Its "pink panthers" – as the company's distinctively coloured service vans were nicknamed – became an increasingly familiar sight in many places. The company expanded with the creation of a Systems Division in its Engineering Department and the creation of an Aircraft Electrical Overhaul Shop in Seletar. Turnover climbed to S$15 million in 1978, compared to $5.8 million in 1974, while staff strength grew from 255 to 343.

Lim was succeeded by Mr Chong Kok Pan. Turnover tripled between 1979 and 1981, and staff increased to 770. Financially sound for the first time since its establishment, it embarked on more creative and ambitious strategies. Under a new Chairman, Kua Hong Pak, SEEL moved to a custom-built complex in Ang Mo Kio, and its engineering capabilities were sharply expanded. Another shot in the arm was administered when Mindef decided to commercialise its Electronic Supply and Maintenance Base (1981), and the Central Missile Supply Base (1983), and placed both under SEEL. The former provided SEEL with a perennial business in the form of maintaining and upgrading all the communications equipment of the SAF, while the latter provided the same steady stream of business with the air-defence equipment of the RSAF.

SEEL was soon in a position to take on major projects. It successfully completed the Changi Airport building automation system, and set up a joint-venture with a German company to develop computer-based systems for industrial applications. The venture wound down with the unexpected demise of the parent company, but the knowledge and experience gained opened a door of opportunity for SEEL in providing electronic systems for major infrastructure-related projects.

In July 1982, as part of its rationalisation of the defence industries, Sheng-Li reorganised SEEL's entire Aviation Division into a new company, Singapore Aero-Components Overhaul (SACO). Now known as ST Aerospace Systems, SACO serviced all aircraft on-board components, while SEEL dealt with ground equipment. In a further effort at rationalisation, SEEL was soon after placed under Singapore Aircraft Industries (SAI; now ST Aero).

All this pruning proved a blessing in disguise. It helped SEEL focus on its own core competencies and its product definition. The management decided that SEEL had to corner its own turf, and decided to concentrate on major systems integration services. It moved aggressively into non-defence areas, including building automation projects and automated carpark management systems, and began manufacturing the components of these systems.

But throughout its roller-coaster ride to prosperity, and even as it diversified into non-defence areas, SEEL never lost sight of its obligations to Mindef. It has provided an essential service in maintaining the communications and electronic equipment of the entire SAF, from radios to radars. It ranks among the foremost in providing the SAF with a technological edge.

Its core capability in systems integration is at the heart of many modern weapons systems, as exemplified in command and control consoles on board naval combatants. One of SEEL's first diversifications was into flight simulations, a vital factor in the RSAF's operational readiness given its limited training airspace. SEEL made an indigenously developed Part Task Trainer and an Advanced Cockpit Procedural Trainer.

SEEL has been providing depot-level repair and maintenance for the Singapore Air Defence Artillery since 1983, as well as for the radar and weapons systems of the RSAF. Since 1985, SEEL has deployed a detachment of technical staff to carry out maintenance on the Navy's communications systems, navigational aids, and fire control systems. SEEL also maintains a Combat Information Centre (CIC) trainer for the RSN at Tuas. The trainer was developed in close collaboration with a European company and provides cost-effective training for operators of the missile corvettes.

In March 1995, as part of an overall strategy to strengthen SEEL's overseas image and identity in the ST Group, the name of the company was changed to ST Electronic and Engineering, and the venerated acronym SEEL became ST E&E. Under its new Chairman, Mr Tien Sing Cheong, and its current Managing Director, Mr Yap Eng Lip, ST E&E rapidly consolidated its existing operations, then set forth to acquire the electronic systems integration businesses of various companies within the ST group. With this acquisition and rationalisation, completed in late 1996, ST E&E expanded to two times its original size, thereby establishing it as a leading player in electronic systems integration in the Asia-Pacific arena.

ST E&E is now a mature, well-managed and self-confident company. Its core business activity is electronic systems integration, engineering development, integrated logistics support and product distribution. Its proprietary products will enable the company to grow steadily by providing it with a solid base for exports. The company has built up a ubiquitous presence in Singapore – from building automation systems to security management, from integrated communications to automated carpark management. It has moved into China, Taiwan, ASEAN and India; and it has also established flourishing partnerships with Western companies.

Above all, the sheer range of its business reveals how technology today has multiple uses, and how the possibilities of crossover from military to commercial uses, and vice versa, can be exploited profitably. ST E&E contains a lesson for the future direction of the defence industries in Singapore.

Philip Yeo visiting McDonnell Douglas, 1985. When it comes to missiles, torpedoes and other modern weapons, the crucial thing is systems integration. For example, the missiles might come from an American manufacturer, the guidance system from India, and the platform, a naval vessel, might be from ST Shipbuilding. The local defence industries' ability to integrate such complex systems into a fighting whole is one of their most important strategic and value-added capabilities.

Men and Machines

The RSAF's premier fighter-interceptor, the F-16. Instead of a conventional array of instruments and controls, the F-16 has a sophisticated head-up display (HUD) and a fly-by-wire control system. This allows the pilot to fly with a minimum of physical movement and a maximum of attention to combat, since he no longer has to look down to check his control panels. Such state-of-the-art interfaces between man and machine have become essential to modern weapons systems.

What wins wars? Men or machines? The courage of individual soldiers on the battlefield or the ingenuity of military scientists and engineers in the laboratory? All of the above, of course, not to mention a whole lot of other imponderables. Yet it is astonishing how often in history has one factor been emphasised at the expense of others.

Consider, for instance, the persistence of the horse, the cavalry. As late as February 1940, a leading military publication in the US was still arguing for the superiority of the horse cavalry over mechanised units. Tanks and armoured vehicles, the journal said, need fuel and tyres; horses don't. Horses can forage for fodder anywhere; tanks obviously can't. Therefore, horses are superior in mobility to tanks. Sounds logical, doesn't it? There was only one thing wrong with the argument: it happened to be false. What's more, the people who advanced the argument with such sublime confidence, ought to have known that it was false.

Look at the date again – February 1940! The Second World War had begun five months earlier when German panzer divisions blitzkrieged their way through Poland, and made mincemeat of Polish cavalry units. But the old romance of warfare – the glamour that cavalry units had acquired over centuries on countless battlefields, the dashing figure of brave men on horses riding to battle in Europe, Africa, and the American wild west – those images took a long time to dissolve.

Disbelieving that horses were obsolete, the US Army had only 450 tanks in 1940 – only "one finger of the fan-like German panzer advance" through Poland, one observer noted – but kept tens of thousands of horses. It took a major military exercise in the US that year to convince military commanders that perhaps it was time to put away their saddles. When all the tanks the US Army possessed were pitted against a force of thirty-five hundred horses, everyone watched in amazement as a "slashing, onrushing mechanised brigade" cut through two hundred galloping horses. The commanders' mouths fell open when a tank brigade thundered over hills overgrown with briars and

bushes, and crossed ravines that horses could not have crossed. It finally dawned on them that tanks "were immune to rifle fire and small machinegun fire" and their beloved horses weren't. It took the US Army almost two years to acquire as many tanks as it had horses.

But alas, perhaps it is possible to learn a lesson only too well. Fifty years after the cavalry receded into history, we saw in the Gulf War what seemed like an apotheosis of mechanised warfare. Desert Storm was presented on TV as an altogether new form of warfare. Precision-guided missiles had fed back images of their flights to mission control, and thence to CNN. We saw a smart bomb dive down the shaft of a Baghdad building. We saw a cruise missile, launched from a ship somewhere in the Persian Gulf, wend its way through hundreds of miles of desert, and blow up a command centre somewhere in the middle of Kuwait. What a wonderful way to fight! No need to risk life and limb – other than the enemy's, of course. Superior electronics alone was enough to win wars. Or so it appeared on TV.

It turns out now that although superior electronics did undoubtedly give the Allied forces in Desert Storm a decided edge over Iraqi forces, the electronic pudding we were served on TV got a little over-egged in the telling.

A major US government study in 1996 revealed that the expensive 'smart' weapons systems did not necessarily outperform cheaper 'dumb' ones. The guided missiles could not tell if a target was a tank or a truck, or whether it was already destroyed. Their sensors – electro-optical, infrared or laser – could not see clearly through clouds, smoke, rain, fog, or high humidity. "One target, one-bomb efficiency", the report concluded, "was not achieved."

The Stealth fighter jet, despite its touted ability to get close to a target while evading detection, did not necessarily outperform older, cheaper aircraft. More ominously, it appears that the Patriot anti-missile system – which initial reports had shooting down 41 out of the 42 Iraqi Scud missiles aimed at Saudi Arabia and Israel – shot down perhaps only 40 percent of the Scuds aimed at Israel and 70 percent of those aimed at Saudi Arabia.

Significantly, the Scuds were finally neutralised, not by electronic means, but by individual soldiers. Special forces, aided by spotter-planes, went into the desert, and took out the Scuds one by one, the old-fashioned way. The commandos didn't go in on horses, of course, but the mechanisation of warfare, all the razzle-dazzle of modern electronics, did not negate the necessity of their courage.

It is clear that modern warfare requires the mobilisation of a vast array of talents and resources. It is clear that deterrence depends not only on the number of soldiers a nation commands, but also the quality of its military technology. But despite these facts, it is also clear that war will never be like a video arcade; that old-fashioned virtues like courage and valour – or that timeless triad: duty, honour, country – remain as relevant in the age of the silicon chip as they were in the age of the cavalry.

Quek Poh Huat

In 1981, Quek left Mindef to work in the Singapore Technologies group. He was President of Singapore Technologies and Chairman of ST Aero when he left the group in 1995. Among his many achievements was overseeing the listing of ST Aero in 1990. Quek is currently President of Temasek Holdings. Trained in Chemical Engineering at Leeds University, UK, Quek subsequently obtained his MSc (Management) from the US Naval Postgraduate School, and attended Harvard Business School's Advanced Management Programme in 1989. He was awarded the Public Service Star in 1994.

A typical day at the ST Aero hangar: fixing up the F-5E IIs.

ST's Air Wing

What was to become the aerospace heavyweight of the region, Singapore Technologies Aerospace (ST Aero), was spared most of the trials and tribulations of the earlier defence industries. It was a business destined to take off. Singapore could not do without an aerospace industry, any more than it could do without air communications, for it was abundantly clear that Singapore would become the regional hub of air travel. The problem was the dearth of expertise in Singapore. A highly trainable work force and some experienced personnel from an existing foreign-owned company provided the kickstart for a homegrown aerospace industry.

Singapore Aerospace Maintenance Company (SAMCO), now known as ST Aerospace Engineering, was set up in 1975. Before its establishment, the RSAF – then known as the Singapore Air Defence Command (SADC) – depended on Lockheed Aircraft Services to service and maintain the refurbished BAC Strikemasters and Hunters which formed the SADC's initial trainer aircraft. Lockheed also assembled and serviced the first batch of McDonnell-Douglas A4 Skyhawks that Mindef had chosen to meet the increasing needs of the SADC.

When the US pulled out of Vietnam, business for Lockheed dwindled and its presence in Singapore could not be sustained. Because Mindef deemed that it was in Singapore's strategic interest to have an indigenous aviation industry to meet the servicing and maintenance needs of the SADC, it decided to fill the gap left by Lockheed's withdrawal. It was encouraged to do so by a group of idealistic young officers in logistics – including Mr Quek Poh Huat, who

The cockpit of the F-5E II.

would eventually become President of Singapore Technologies Aerospace and of Singapore Technologies Holdings. This group of logistics officers was much taken with the prospect of commercialising as much of Mindef's operations as possible. Besides the requirements of defence, Mindef also had its eye on the potentially unlimited scope of the regional aerospace industry.

Spearheading the formation of SAMCO, ST's maiden venture into the aerospace industry, was Mr Patrick Wong Yeok Yeok. Mindef put up S$3 million in working capital, as well as hangar facilities in Seletar Air Base.

SAMCO cut its teeth on the maintenance of all of RSAF's aircraft. In 1977, SAMCO was joined in the aerospace business by Singapore Aero-Engine Overhaul (SAEOL) – known in its previous incarnation three years earlier as the Singapore Airlines (SIA) Engine Overhaul Base. SAEOL (now ST Aerospace Engines) was initially set up as a joint-venture with SIA to overhaul the engines of SIA and the RSAF. In 1982, ST Aero bought over SIA's share of the company and SAEOL became 100 percent ST-owned.

The next milestone occurred after Mr Howe Yoon Chong took over as Defence Minister in 1979. A firm believer in airpower, Howe was determined to make the RSAF a potent force. But he also believed in extracting as much bang as possible from every buck spent on military hardware. And so, instead of buying the latest available aircraft, Mindef scoured the Davis-Monthan Air Force Base in Arizona, USA, for the carcasses of mothballed A4 Skyhawks. The task of rebuilding and refurbishing these carcasses was undertaken by SAMCO. About 60 Skyhawks were eventually retrofitted and modified, giving the RSAF the wherewithal to meet its training and operational needs cost-effectively, and giving Singapore's fledgling aerospace industry the kind of experience that money could not buy.

ST Aero's maintenance capabilities extend beyond fixed-wing aircraft and includes several helicopter types, both commercial and military.

Aloysious J D'Cruz

D'Cruz has been working on airplanes since the old days of Malayan Airways. Over the years the outfit he has worked for has changed names and owners – Malaysia Singapore Airlines (MSA), then Singapore Airlines (SIA) and finally ST Aero – but D'Cruz has kept at his job. He has watched the Singapore aerospace business grow from servicing DC3s to servicing B747s. Currently a shopcontroller in ST Aerospace Engines, D'Cruz used to build model planes as a boy, but "now he gets to build real planes, their engines too".

R Balakrishnan

Balakrishnan's aerospace engineering career began 19 years ago with Lockheed Air Services, Singapore, which then had a contract to maintain and service RSAF aircraft. He briefly served in the RSAF as a structural engineer, before joining ST Aerospace Engineering. Balakrishnan has made significant contributions in the area of engineering design and technical services in ST Aerospace Engineering's RSAF refurbishment and upgrading programmes, as well as in its non-defence commercial ventures. Currently Senior Manager (Engineering Services and Programmes), Balakrishnan has a Bachelor's degree in Science and another in Aeronautical Engineering.

Installing the F404 engine into a Super Skyhawk.

The Black Knights, the RSAF's aerobatic team, first took to the air in 1974. They originally flew the Hawker Hunter. In 1981 the aerobatic team took on new planes and a new name. Equipped with the newly acquired supersonic F-5E Tiger IIs, the team was called, appropriately, the Flying Tigers. They have since switched planes again, and are currently using ST Aero's re-engined A4SU Super Skyhawks, and have renamed themselves the Black Knights.

The refurbishment of the Skyhawks gave SAMCO the confidence to reach out for new challenges. When the RSAF decided to replace its Alouette helicopters with Bell Hueys, SAMCO took it as an opportunity to develop its rotary wing capabilities, adding another dimension to its operations, a crucial one given the importance of helicopters to the SAF. Yet another opportunity to extend its range of operations arrived when the RSAF decided to phase out its BAC Strikemaster trainers with the up-to-date SIAI Marchetti S211. An agreement was reached with the manufacturer for SAMCO to assemble and customise these aircraft in Singapore.

An important milestone was reached when the RSAF became dissatisfied with the reliability and operational readiness of the Skyhawks. Though the airframe of the aircraft was sturdy, its Curtiss Wright J-65 engine was underpowered and spare parts for the engine were difficult to obtain. As a result, the RSAF suffered frequent, to put it delicately, 'aircraft-on-ground' situations. Mindef seriously considered withdrawing the Skyhawks from the RSAF's frontline, but decided that it could not "wish away the A-4 fleet". As BG Lee explained: "Buying a whole new fleet of aircraft was out of the question. It was not only exorbitantly expensive, but also politically insensitive." Mindef decided, instead, to upgrade the Skyhawks with General Electric's F404-GE-100D non-afterburning engine. Engineers from SAMCO and Mindef/RSAF designed and worked on the upgrade in SAMCO's facility.

To accommodate the F404 engine, SAMCO had to make major structural changes to the Skyhawks. The airframe had to be gutted and strengthened to accept the more powerful engine, intakes had to be modified, and new aircraft systems had to be designed and incorporated. Many new components had to be installed as the modifications progressed, including a 40 KVA generator, an air turbine starter and a refrigeration unit.

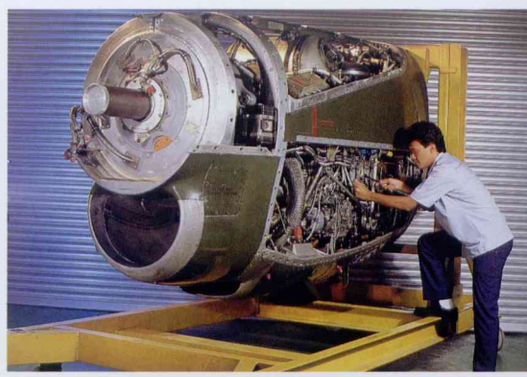
The programme proved an unqualified success. With the new engine and modifications, the sea-level climb rate of the Skyhawk increased from 8,000 feet per minute to a startling 18,500. The upgrade also improved the plane's take-off weight and its payload capacity. The later F-5E/F, which the RSAF had also acquired by now, required its afterburner to catch-up with the upgraded Skyhawk. Renamed the Super Skyhawk, the plane was selected for the RSAF's "Black Knights" aerobatics team.

But the modifications done so far were only phase one. The investment was pushed to the limit with the installation, in phase two, of an advanced avionics upgrade. A Ferranti weapons delivery and navigation system (WDNS) was added, and the Super Skyhawk was turned into a formidable weapons platform.

By this time, Sheng-Li had consolidated the defence industries' aerospace activities under the umbrella of Singapore Aircraft Industries (now ST Aero), which soon became a large integrated industrial complex.

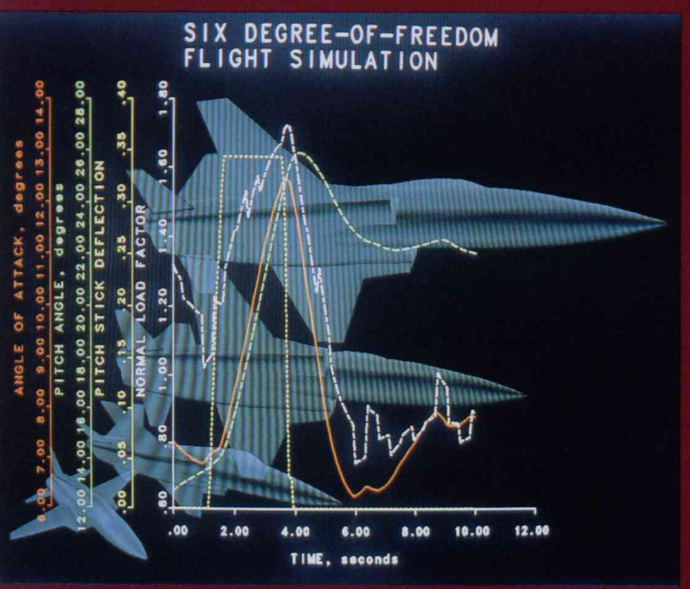
SAEOL became the authorised service centre and overhaul facility for engines powering the C-130s, T-5Es and other aircraft, and received certification from the Federal Aviation Authority of the US for a wide range of engine maintenance services. SAEOL's operations included repairs down to the smallest components such as fuel pumps and nozzles, and the use of robotic plasma and flame spray systems for complex engine parts. SACO continued to overhaul and maintain aircraft components, while Singapore Aircraft Manufacturing produced an impressive array of aircraft parts – including, currently, 58 parts for the Pratt & Whitney PW4000 engine, which powers various Boeing, Airbus and McDonnell Douglas aircraft. Other subsidiaries were set up as demand broadened and economies of scale began to emerge. Singapore Aerospace Warehousing Services (SAWS; now ST Aerospace Supplies) was set up as the group's purchasing and warehousing agency.

Following the upgrade of the Skyhawk, SAMCO set its sights on an even more ambitious programme – the upgrade of the F-5s. This project, the most advanced and complex upgrade ever undertaken on the F-5 platform, was announced in early 1996, and was expected to extend the frontline life of the aircraft well into the next century.



ST Aero is fully equipped to repair and overhaul a wide range of airplane engines.

Making a Plane Last: The F-5 Upgrade



Of the 2,600 Northrop F-5 Tiger II fighters built since the first production model in 1972, 1,600 are still in active service among 26 air forces. The stiletto-shaped, twin-engined aircraft was developed by the US in response to urgent calls from friendly and allied developing nations for a modern, reliable, supersonic, air-superiority fighter which could be maintained and operated with indigenous engineering support. After 25 years of service, the F-5 still delivers on its promise. It has shown itself amenable to dramatic modernisation, which will keep it in the front-line inventory of air forces well into the next century – and this, at a fraction of the price of a new product.

Among the major aerospace companies which have developed upgrade packages, Singapore Technologies Aerospace (ST Aero) has one of the most comprehensive and exciting. Its package will vastly enhance the F-5's air combat and ground attack capabilities, and improve the plane's weapons delivery and navigation systems, as well as the so-called 'situational awareness' of the pilot, the focus of the upgrade programme.

The ST Aero upgrade package is available as a range of options, allowing operators to customise the avionics to their operational needs, and choose additional components as and when they are needed. The conventional avionics suite, with miles of bulky cables, can be replaced by a black-box system using a single electronic multiplexed digital switching connection; and the present radar can be replaced by a new multi-mode radar which will provide a 'look-down, shoot-down' capability, enabling ground attack and anti-shipping operations.

The start-up upgrade comprises a modern digital Mission Computer, an Air Data Computer, an Inertial Navigation System, a wide-angle Head Up Display (HUD) system, Hands On Throttle and Stick (HOTAS) controls, and a colour video HUD camera and recorder for highly accurate weapons delivery and navigation systems.

The addition of either one or two Multifunction Displays (MFD) to replace the conventional instruments panel will further enhance the

man-machine interface of the aircraft. Both MFDs as well as the HUD are within the pilot's field of view while he operates the plane 'heads-up and eyes-out'.

A Data Transfer System (DTS) provides quick input of mission data – such as weapons programmes, stores inventory, and route and avoidance zones – into the aircraft system, while downloading critical data – such as marked points – during the flight.

At a further level of upgrade, the whole nose of the aircraft can be redesigned to allow the installation of a modern multi-mode radar with enlarged antenna for vastly superior performance.

The F-5 upgrade programme is a big leap from ST Aero's earlier Super Skyhawk upgrade in 1988, far more challenging because of the level of technology involved in the systems integration. Even more improvements for the F-5 are on the drawing board at ST Aero.

The SAF is equipped with a modified French-designed AMX-13 light tank. Designing and producing its own tank might not make sense for Singapore, but that does not mean that Mindef can just buy them off-the-shelf. A local defence industry provides Singapore with the capability to modify military equipment to best suit its soldiers, the local operating environment and the requirements of the SAF.

The Complete Consort: Total Defence

The defence industries were initially set up to support the SAF against a backdrop of potentially destabilising developments in Southeast Asia in the late 1960s. After the British announced their withdrawal from "east of Suez", the governments of the United Kingdom, Australia, New Zealand, Malaysia and Singapore established the Five Power Defence Arrangement to provide an important psychological deterrent: any aggressor would have to contend with the collective response of the five members. Collective security, however, cannot be a substitute for national security. Ultimately, Singapore's defence has to be secured by Singaporeans themselves.

The measures, thus, that Singapore took in the late 1960s to further her security interests were less an option than an imperative. The SAF had to be built up at the fastest pace possible, limited only by the learning curve of Singaporeans; and Singapore's approach to national security had to be holistic.

It was recognised from the outset that national security cannot be detached from the rest of society. Singapore's military viability lies, firstly, in its high degree of operational readiness, and secondly, in its ability to marshal all of the island-state's potential. This double recognition is now codified in the national ethos of Total Defence, incorporating military and civil defence, as well as psychological, social and economic defence. The doctrine of Total Defence sends a clear signal that any potential aggressor would be faced with the formidable task of taking on all sectors of Singapore society, acting in concert, rather than the SAF alone.

The early development of the SAF comprised four concurrent activities – the formulation of the national security strategy, the training of troops, the establishment of the force structure, and the equipping of the forces. The role of the defence industries was to raise the indigenous component of the last element to the point of virtual self-reliance in the provision of essential war-fighting material and services, but on a value-added basis. It was also believed that the defence industries could generate economic returns from the defence budget, as well as provide the SAF with a technological force multiplier.

Taken as a whole, the verdict after 30 years can only be that the defence industries have achieved these aims very substantially. It is partly because of ST's defence-linked components that the SAF can now field the most sophisticated military equipment in the region. There can be no doubt that the defence industries have delivered on their promise to give the SAF a technological edge over potential adversaries.

But new challenges lie ahead. Born in the analog age, and transitioning smoothly into the digital age, the defence industries are now faced with two revolutionary developments in the field of military provisioning. The first is the eclipse of dumb munitions by smart precision-guided munitions, a development which has reduced the importance of quantity in favour of quality of products; and the second is the shift of the cutting edge of technology from defence R&D to the commercial sector. These developments – together with the already noticeable reduction in demand from the SAF since it fulfilled its strategic stockpile requirements – have brought the defence industries, especially those which are product-based, to a difficult point in their journey.

There is no doubt, however, in which direction they must head – Forward.

ST E&E has been working on flight simulators since 20 years ago, when the company was contracted to upgrade and maintain the RSAF's first aircraft simulator. Over the years, ST E&E has had the opportunity to collaborate with established manufacturers to jointly develop and maintain various simulators for the RSAF. Leveraging on this experience, the company started its own simulator R&D. The result is the Aviation System Trainer (AVIST). The first product, the Part Task Trainer, was launched at Asian Aerospace '92, and a phase 2 product, the Advanced Cockpit Procedural Trainer (shown here), was launched at Asian Aerospace '94.

Lye Fei

Lye has given management support to Singapore Technologies in many capacities. Currently Deputy President of STIC, President of ST Energy and Group Director of ST, he has also served as a Senior Vice President and General Manager of ST Auto and as President of CIS. Lye holds a Bachelor's degree in Engineering and a diploma in Business Administration from the University of Singapore.

As GM, Lye played a key role in the turnaround of ST Auto from 1986 to '89. In 1986, business from Mindef was drying up, commercialisation was not profitable, productivity was low and internal organisation had problems. Lye recalled: "Our main priority then was to get business. ST Auto succeeded in re-establishing close ties with Mindef and secured contracts with them for ST Auto upgrading kits. The second priority was to build a strong management team. We embarked on a value systems and culture building programme and it took nearly three years to build up a real professional and strong team. In my opinion this was a main factor in our success."

Double Ace

Question: How do you organise a world-class aerospace exhibition in a country whose total airspace is less than two minutes flying time in any direction?

Answer: Very, very carefully!

The fact that the exhibition has to take place in the airspace of one of the world's busiest air-hubs, does not make things any easier.

A brainchild of Philip Yeo, then Permanent Secretary of the Ministry of Defence, the Asian Aerospace (AA) exhibition had its modest origins in the arrival hall of Paya Lebar Airport. The UK-based International Trade Fair (ITF) organised the exhibition. Ten aircraft on static display, some other defence exhibits, and one solitary flying display by an MBB BO 105 (displaying upside-down flight), provided the highlights of the exhibition. Modest as it was, the show was a qualified success.

The 1984 and 1986 exhibitions were held in the RSAF's Changi Airbase, which allowed for more ambitious programmes and flying displays than Paya Lebar. ST Aero (then Singapore Aircraft Industries or SAI) played an important but informal role. The connection was established after the 1984 show, when the ITF realised that SAI's participation would add potential to the show.

In August 1986, Philip Yeo encouraged a joint-venture between SAI and Cahners (the parent company of ITF) to organise the exhibition. This partnership was incorporated as Asian Aerospace Pte Ltd, a joint-venture between SAI and Reeds Exhibition Co (Cahner's parent company). In order to improve the exhibition, the Civil Aviation Authority of Singapore facilitated the construction, in a record 18 months, of an exclusive exhibition site at the Changi Airport area, the Changi Exhibition Centre. This site then became the venue of the AA Exhibition.

With 12,000 square metres of space, the 1988 show was a quantum leap in size and number of exhibits when compared to previous shows. The Civil Aviation Authority re-scheduled flights to close the two-runway Changi Airport for about an hour each day of the show to permit air displays. By 1992, aerospace industry watchers were already beginning to call the AA Exhibition a world-class airshow.

The Exhibition, however, did not achieve this prestigious status without its fair share of hiccups along the way. The teething problems of the initial shows were considerable – from sound systems that broke down to underpowered airconditioners, from a shortage of hotel rooms and rental cars for visitors to long lines for tickets to the public shows.

But all that has changed in recent years, and professionalism reigns in everything. Clockwork precision, immaculate protocol, streamlined organisation and superb hospitality have become the hallmarks of the show. Hotels are booked way in advance, tour agencies have learned to factor the AA season into their planning, and tickets for the public are distributed weeks ahead of the show through an island-wide network of ticket outlets.

Over the years, the constraints of ground and air space have actually made the Asian Aerospace format tight and snappy. Static displays are packed close, in an imaginative mix of civilian and military exhibits, together with hospitality chalets, public food courts, and souvenir stalls. In a relatively small outdoor area, the dramatic shapes of aircraft – sleek, deadly, purposeful, and occasionally whimsical – excite the imagination of children of all ages. With 14 or 15 events squeezed into the single hour allocated each day for the air display, avid spectators get a non-stop show of dazzling aerobatics. The performers hit the high spots of their performances quickly, for they are each given only three to five minutes to show their paces.

Singapore's biennial Asian Aerospace exhibition is now ranked third among the aerospace exhibitions of the world, after Paris and Farnborough. It has become a must for aerospace and defence manufacturers, for it is widely perceived that if they do not participate at the big 'Double A', they might well miss out on opportunities in the Asia-Pacific region.

It is not surprising, therefore, that the show has become the venue of choice for the Asian debuts of exotic hardware and products, and for dramatic disclosures of coming attractions, partnerships and multi-million dollar deals. For the 1996 show, the fabled US B-2 Stealth bomber sneaked out of its lair on Guam Island for a two-hour stopover (with engines running), and created widespread excitement among the jampacked crowd. At the 1994 Exhibition, Professor Dr B J Habibie, Indonesia's State Minister for Research and Technology and architect of his country's aerospace industry, announced Indonesia's commitment to developing the much discussed IPTN N-250 turboprop airplane. In 1992, Airbus Industries sent its prototype A340-300 airplane on a non-stop flight from its Toulouse factory, although the aircraft was only a third of the way through its certification programme. That same year, the Confederation of Independent States, formerly the USSR, blocked out the sky over Changi with its behemoth Antonov AN-124; while ST Aero unveiled its relatively diminutive Super Skyhawk, with its new F404-GE-100D turbofan engine.

Asian Aerospace '96 affirmed the world-class status of the Singapore show, and if things go as predicted, it could become *the* show.

CHAPTER THREE

MAKE IT NEW

Even as they grew from strength to strength, Singapore's defence industries realised from very early that they would remain commercially viable only if they leveraged on their skills to move into non-defence areas. Thus was sown the seeds of a diversified conglomerate that, by the end of the 1980s, had more civilian than military business. The first stage of diversification saw the defence companies use their core competencies to expand into non-defence areas and spin-out their 'service' components into stand-alone companies. The second stage of diversification saw an extension of the group's core competencies into riskier but more rewarding areas like semiconductors, and the emergence of ST as a broad-based technological company. By the 1990s, ST was among the vanguard leading the island-nation into high-tech, high value-added activities.

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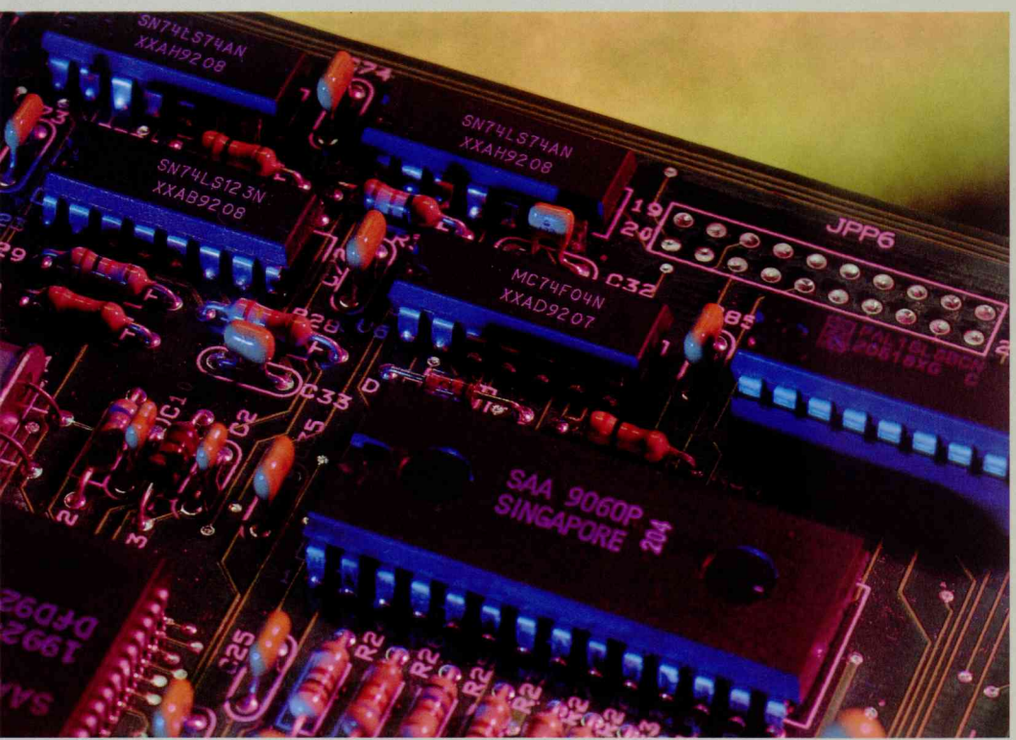


MAKE IT NEW

新 *['Hsin' or New]: From hatchet, to erect, and wood. To cut down wood. Fresh, new; to renovate; to renew or improve the state of; to restore or to increase what is good, applied to persons increasing in virtue; and to the daily increase of plants.*

Morrison's Chinese Dictionary

The pattern is new in every moment.

T.S. Eliot

The command, 'make it new', is very ancient. The preceding Chinese ideogram for the concept 'new' is found in the *Ta Hio*, a 12th century Confucian text. The Master tells his disciples of the story of King Tching Thang who had inscribed the character for 'new' together with the ideogram for 'day' (sun) – 新, 日日 新 – on his bathtub to remind himself every morning that "The Law of the Great Learning, or of practical philosophy, lies in that luminous principle which we have received from the sky: Renew humankind, and place it on the path to Perfection."

"New, day by day, make it new." A people who cease to learn will die, for the law of life is change, renewal. It is impossible to step into the same river twice; the river is new in every moment.

Fortunately for Singapore Technologies, its people, senior management and staff, realised these truths from the beginning. They knew that to survive they must embrace change. They knew that the act of faith which instigated the formation of CIS in 1967 was not an act that happened once in history and could then be safely forgotten. If the possibility of growth was to be kept alive, that act of faith had to be repeated over and over again. Like King Tching Thang, ST could not cease cutting down wood if it was to restore and increase what was good.

In many respects, this process of renewal began almost from the beginning. There was an awareness from the start that to survive, the defence industries must use their competencies to expand into non-defence areas. The experience that companies like CIS gained in using their core competencies to do a variety of things beyond their primary business, helped ST prepare for the long-term decline in defence sales. It became clear in the late 1970s, about ten years after the founding of CIS, that ST had to prepare itself in advance for this decline if it was to continue growing.

Against this background, three stages in ST's diversification may be specified. In the first stage, which began almost at the inception but gathered speed from the late 1970s onwards, ST moved into areas which, though they had a defence-related component, were in the main commercial and industrial activities that extended the core defence-related competencies. This period saw the 'service' components of the defence industries being spun-off into stand-alone companies.

In the next stage of diversification, which began tentatively in the early 1980s but proceeded more aggressively as the decade unfolded, ST expanded beyond its initial core competencies into new technology areas like IT and semiconductors. It was in this stage that ST emerged as a broad-based technological company, nurturing and developing fledgling businesses in emerging technologies.

The third stage is the regionalisation and globalisation of ST's operations, a seed first planted in 1986, but a development that is still in its infancy. This will be a subject for the next chapter.

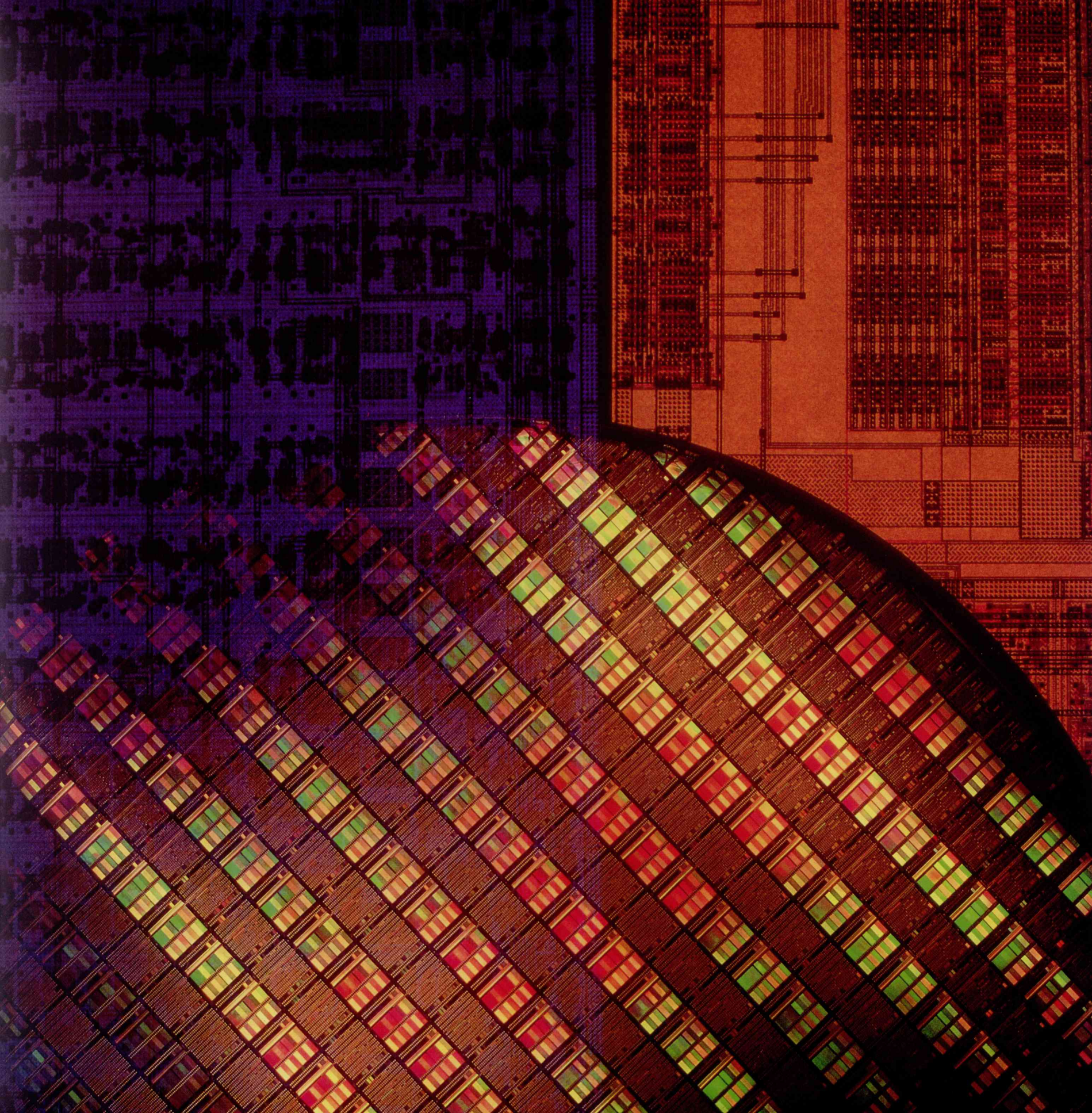
Opposite Page
Semiconductor wafers are thin pieces of silicon, six or eight inches in diameter; integrated circuits are then etched or sputtered onto tiny sections, which in turn are eventually cut out as individual chips and packaged in black epoxy casings. These are the integrated circuit chips which find their ways into countless electronic devices from computers to home appliances to quartz watches.

Cluster bombs. It is a long journey from making things for the military to manufacturing semiconductors, but not an improbable one. In the case of ST, the competencies mastered in the defence industries – precision engineering, quality control and high technology – provided the base for venturing into other high-tech industries, including semiconductor wafer fabrication. In fact, CIS provided the capital for ST's foray into the semiconductor business, thus the word 'Chartered' in Chartered Semiconductor Manufacturing.

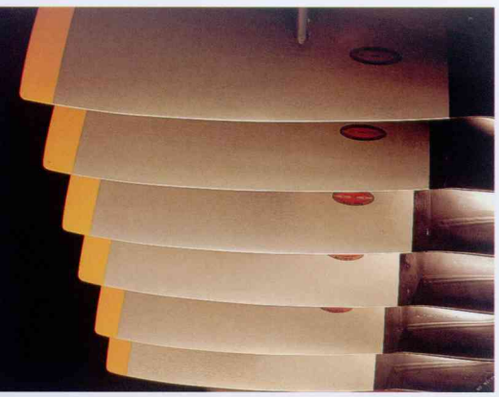
The transition, of course, from one stage to another – from extending core competencies to expanding beyond them, and then into the region – cannot be sharply distinguished from each other. For one thing, the stages overlapped each other: the second stage began even as the first was gathering momentum; and the third was being explored even as the second got underway. Also, there was a certain continuity of development, and the first stage prepared the way for the second and the third. At every stage of its development, moreover, ST exhibited certain characteristic traits. It has always grown by leveraging its skills; it has always been willing to push itself beyond the boundaries of the done, the accomplished, the familiar. In this respect, the ST of 1997 is much the same as the ST of 1967.

But as the 1980s shifted to the 1990s, it became clear that ST's field of operation had become wider. Its focus on technology, for instance, grew to encompass technology as a whole. The ST of the 1990s has become a microcosm of Singapore's globalised economy.

This chapter will detail the first two stages of ST's diversification, and some of the risks ST took in going beyond its comfort zones. This process was by no means painless. The survival, let alone success, of some ST ventures was by no means certain; some, like CSM, seemed headed for failure. The story of how success had to be wrestled out of failure – of how the 'rose' of opportunity had to be plucked from the nettle 'danger' – will serve as a reminder that the going will only get tougher as ST climbs up the technological ladder. If the rewards are greater, so are the risks, and consequently, the skills required to succeed.



Ploughshares From Guns



Jet engine turbine blades.

In Singapore's far southwestern corner, the Benoi River meanders through the swampland-turned-industrial-estate that is Jurong. Near the mouth of the river, just a few kilometres from the munitions factory where Singapore's defence industry was born in 1967, lies the shipyard of Singapore Technologies Shipbuilding & Engineering (ST Shipbuilding). On any day, a visitor to the yard will note vessels belonging to the Republic of Singapore Navy being repaired or built, or being fitted out with various systems.

The Benoi yard continues today to fulfil the purpose for which it was conceived in 1968: equip the Republic's Navy. But any illusions that ST Shipbuilding is purely a defence contractor will be sunk swiftly at the sight of the other occupants of the yard. For the visitor will note that the Navy's boats are dwarfed by commercial vessels, including container ships in customary red and black, being repaired or built from scratch. Indeed, while Navy orders continue to keep the yard busy, the most majestic sight witnessed recently was the launch in 1995 of the container ship "MV Anan Bhum". The first in a family of four custom-designed vessels, it was some 140 metres long and able to carry 1,018 twenty-foot containers or their equivalent – the largest container ship ever built in Singapore.

In 1996, only about 45 percent of ST Shipbuilding's revenue came from military contracts, and the rest was from commercial jobs, ranging from the conversion of seismic vessels and refurbishing luxury yachts, to designing and installing fire-fighting systems on supply ships, and repairing chemical tankers and dredges.

ST Shipbuilding's hybrid portfolio is a microcosm of the Singapore Technologies group: namely, its dual function of providing hardware for the military and commercial products for civilian clients. As the last two chapters have shown, there would have been no ST without the defence industries. Sales turnover from defence continued to rise well into the 1990s. But as a proportion of the group's total sales, it shrunk markedly. By 1984, defence accounted for 57 percent of the group's turnover. By 1989, it fell to less than half, or 45 percent. In 1995, it was just over one-quarter, or 27 percent. It is expected to fall to under 15 percent by the year 2000.

If ST were a tree, what kind of tree would it be? If the diversified group were to be likened to a tree in Singapore's minimalist rainforest, it would not be an *angsana* or one of those other species with clearly identifiable roots, trunk and branches. The intriguing banyan would be the more appropriate metaphor. From its spreading branches, the banyan sprouts aerial roots that reach the ground and then thicken into columns or walls of prodigious proportions. In a mature specimen, it is impossible to tell which is the original trunk and which are the roots, or what exactly is propping up the main weight of the tree, or whether there is just one tree or two or more neighbours growing into each other.

Similarly, looking at the businesses in the group in the 1990s, observers would have to be excused for wondering at the breadth of activities, and whether and how they related to any core mission or competence. The group's non-defence work included servicing airplanes, making

The "Tropic Tide", a 400 TEU RoRo/LoLo type Container Vessel built by ST Shipbuilding. The ship, built in 1993, has received strong praise from its owner, the US-based Tropical Shipping & Construction Company.

roast meat, building industrial parks, retailing consumer goods, and providing financial services.

Trying to find synergies among these disparate enterprises – or at least a rationale for why they belonged under the same canopy – would prove a major preoccupation for the group's corporate executives. As with the banyan tree, it would sometimes be hard to decipher how precisely the different elements of ST constituted a whole; or whether the singular organism would be hurt by, or benefit from, some major pruning.(The story of that corporate challenge comes later, in Chapter 5.)

It is less difficult, however, to trace historically how the group grew. A snapshot would show an entity of bewildering complexity; but its evolution, like the banyan tree's, was organic. The breadth of ST's work was very much a reflection of the multiple needs of its main customer, the Singapore Armed Forces. As unrelated as ST's civilian businesses may have seemed to each other, all of them, at least until the mid-1980s or so, could trace direct historical links to defence-industrial activities.

ST's vehicle testing centre is a case in point. One of a few in Singapore authorised to provide mandatory tests for private vehicles, it was developed from the group's competence in army vehicle maintenance and repair. Similarly, ST's food business arose from supplying food to the SAF; and its retail chain, SAFE, had its modest beginnings as a supermarket for SAF personnel. (SAFE was first established to moderate the prices of essential foodstuff, like rice and sugar, which were increasing at an alarming rate in the early 1970s because of inflationary pressures worldwide. The duty-free beer it sold was also popular with SAF personnel, who otherwise led rather spartan lives in their then spare camps.)

Nowhere, however, was the trend towards commercial non-defence business more clearly seen, or the forces underlying it so apparent, than at that site along the Benoi River.

There was no mistaking the rationale for setting up in 1968 what was then called Singapore Shipbuilding & Engineering. Dr Goh Keng Swee wanted Singapore to have the capability to build its own naval boats. The fledgling navy then had just two vessels: the "RSS Panglima", built in 1957, and the "RSS Bedok", which started life as a police boat.

However, from the start, the shipyard's future was tied equally to civilian clients. It bidded successfully for a number of commercial contracts. Thus, in 1970, the first vessel built by the company was not for the military at all, but a 25-metre ferry for the Sabang Free Port Development. In 1972, when the first gun boats were launched, the company also built two mini bulk carriers for a Panamanian client. This pattern continued through the years. The company built naval and paramilitary craft for Singapore and foreign clients, and, simultaneously, various commercial vessels: liquefied petroleum gas tankers, container vessels, passenger ferries, and yachts, among others.

Quality control has always been an essential part of ST. From the beginning, CIS made it a priority that all products should be of uncompromising quality. This attention to detail continues in every ST enterprise today, whether commercial or military, from complex high-tech manufacturing to basic repair services.

There were good reasons for not limiting the yard's work to supplying the Navy. It was clear from the start that defence jobs would not be enough to sustain the company. Singapore's Navy has always been the smallest of the three services. Although there was never any doubt that defence of the island-port's shores and sea lanes was non-negotiable, it was felt that this could be accomplished by the use of airplanes and helicopters, and not necessarily just boats.

Mr Goh Chok Tong, when he was Defence Minister, was candid on this point: given limited resources, he said, he would rather "have a modern aircraft instead of a modern ship". "I think in our context it is the Air Force which gets the best, and the Navy, unfortunately, as you know, does not get the best." This philosophy was expressed in the relative manpower figures for the two services. According to the International Institute of Strategic Studies, Air Force manpower doubled between 1976 and 1986, while the Navy's increased by just 50 percent over the same period. Singapore's defence planners were not about to forget the lessons contained in the fates of two impressive battleships, the "Prince of Wales" and the "Repulse", that the British had sent to the South China Sea to deter the expected Japanese invasion of Malaya and Singapore in 1942. Japanese planes sank them.

While the limited size of the local defence market was evident to the shipbuilders earlier, this was not a situation unique to them, by any means. Sooner or later, all arms of the defence industries would have to grapple with the finite needs of the Singapore Armed Forces, and either penetrate foreign markets, or diversify into civilian businesses, or both, as in the case of shipbuilding.

As BG Lee Hsien Loong, addressing CIS staff on their 25th anniversary in 1992, noted:

> It makes sense for both the defence industries and the Singapore economy that the defence industries should venture beyond military business. It gives the companies a broader operating base to buffer the uncertainties of defence sales. Military business is volatile. The relaxation of global tensions [in the post-Cold War era] is beyond question a favourable development, but defence companies around the world worry that it means less business for them. The SAF's requirements also fluctuate.
>
> Some are one-time requirements: now that the SAF has equipped every soldier with a rifle, it will be quite some time before it needs to replace all the rifles with new ones. Others are contingency requirements: the amount of ammunition used during peacetime training is a tiny fraction of what will be needed in war. We cannot keep production lines and engineers idle for years, against the possibility that we may need them one day in an emergency. The equipment will rust, and the people will leave. Singapore Technologies' non-defence business enables the group to contribute to Singapore's economic growth and development, instead of being a drain on the nation's resources.

Indeed, the state's need to get some peacetime pay back from its heavy investments in the defence industries was felt from the start, when CIS was set up in 1967. The same compound on Jalan Boon Lay that churned out rounds for rifles, also produced coins, for the government located the national mint in the same place. The mint was built on one side of the main car park, at right angles to the CIS administration building, and continued to supply the growing economy's loose change until 1996, when it was relocated.

Lai Chun Loong recalled: "Being an ammunition company required us to be a good toolmaker, with tool rooms, and a security system; so when the government needed a mint to be set up, it was natural to park it within our place."

"I think Dr Goh felt able to drive the industrialisation of Singapore through CIS. You could see spinoffs in later years", he added. "When we fulfilled our deliveries to the SAF, Dr Goh pulled us up and suggested that we might make doorknobs for HDB flats. He asked if we could convert our machines to make them, and also spark-plugs."

Lim Ming Seong

Lim is currently Group Director of Singapore Technologies Pte Ltd, Chairman of ST Capital and the Vertex Management Group, Deputy Chairman of CSM, and a director of other ST companies. He also has served as a GM of SEEL (now ST E&E), as well as Chairman of SEEL, CSM, ODE and ST Aero. Lim joined Mindef in 1970, and held several senior appointments, including Director of Logistics and Deputy Secretary, before he left to join ST in 1986. He has a First Class Honours degree in Mechanical Engineering from the University of Toronto, Canada, and a diploma in Business Administration from the University of Singapore. He completed an Advanced Management Programme at INSEAD, France, in 1985, and another at Harvard University in 1989.

Singapore Technologies Logistics, formerly Chartered Materials and Services, is one of the leading logistics management companies in Singapore. The company specialises in materials management, freight forwarding management, procurement and general insurance services.

Making Money

Making money is serious business. For one thing, not everyone can be allowed to participate. It is a business where the producers of fake or shoddy goods do not necessarily go out of business. Bad money can literally mean the death of good money.

That is why the minting of coins has always been a special business. In 17th century England, no less a person than Sir Isaac Newton, the great physicist, was appointed the Warden of England's Royal Mint. When not doing his physics, Newton devoted his considerable genius to campaigning against wily counterfeiters, and sent several of them to the gallows.

The danger of counterfeit is one reason why for almost 150 years after the founding of modern Singapore, borrowed or shared currency was used as the medium of exchange. Early in the 19th century, the Spanish dollar, and then the Indian rupee, were legal tender on the island. Later, British India's Calcutta Mint struck coins for the Straits Settlements of Singapore, Malacca and Penang.

From 1938 to 1967, Singapore, Malaya, and Brunei shared a common currency. Older Singaporeans will remember coins and notes bearing the regal profiles of King George VI or the young Queen Elizabeth II. They will also remember that between 1942 and 1945 the currency was the Japanese Occupation's 'banana' currency – so-called because of the banana tree displayed on the notes.

The Singapore dollar was born in 1967 when Singapore, Brunei and Malaysia decided to have separate currencies. Singapore's Board of Commissioners of Currency commissioned the Royal Mint in London to meet the Republic's immediate needs for coins.

By the following year, 1968, when the Singapore Mint was established, Singapore was making its own coins. Dr Goh Keng Swee, recognising that minting coins required precision engineering and high security – two factors also needed in the manufacture of ammunition – set up the mint as a department of the Chartered Industries of Singapore. The mint was housed within the same large compound as CIS at Jalan Boon Lay.

Though the craft of minting coins is several millennia old, the Singapore Mint has had to improve and innovate constantly. Unlike the national mints of most other countries, the Singapore Mint is run on a commercial basis.

As Ms Chong Phit Lian, GM of the mint since 1990, noted: "Most national mints automatically get jobs from their governments. Despite being a government-linked company, we don't have this privilege. Every circulation coin project that we take on for the Singapore Government is won on a tender basis. And while a lot of countries do not invite other mints to quote for their projects, the Singapore government adopts a free-market policy and invites other mints to tender for its projects."

Operating costs at the mint have risen recently because of the sophisticated security features that have to be incorporated in coins to prevent counterfeits. Meanwhile, the government has been pushing Singapore towards becoming a cashless society through the use of electronic smart-cards and other means, shrinking

further the already small domestic market for currency.

Singapore Mint has responded to these developments by entering foreign markets and producing not only circulation coins but also commemorative sets for numismatists, ingots, medallions, and other collectibles.

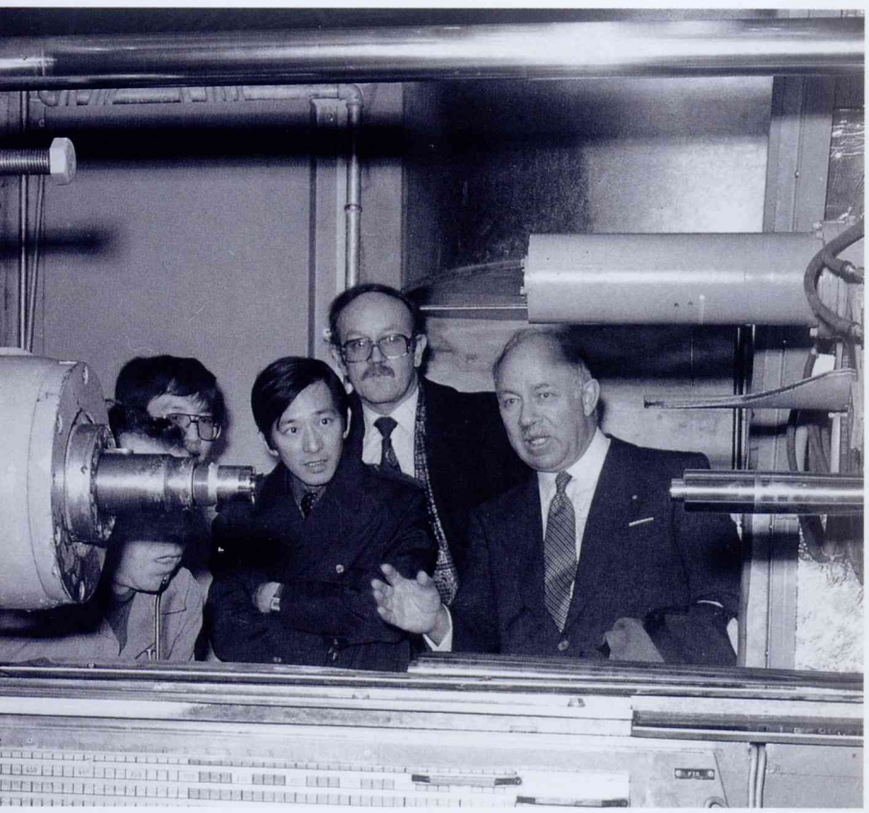
It has achieved a sterling track record. In 1969, it was entrusted by the Currency Board with the task of making the Republic's first gold coins, to commemorate the 150th anniversary of Sir Stamford Raffles' founding of modern Singapore. In the 1970s, the mint ventured abroad. Its first major overseas commission was to make 20 million pieces of 50 Centavos coins for the Philippines. Other foreign customers included Bangladesh, Brunei, Nepal, Uganda, Taiwan, Bermuda, Fiji, Switzerland and Malaysia. In 1986, its design of a Kon-Tiki Expedition commemorative coin set for Western Samoa won the Most Artistic Coin Award in a competition organised by an international trade magazine.

The mint stayed in its Boon Lay birthplace until 1996, when it moved to its new home at Teban Gardens Crescent. The new building includes a Coin Gallery. It displays the mint's entire repertoire of currency, as well as specimens from the early days of Singapore when trade was conducted with coins bearing inscriptions in other languages and from other lands.

Our money has come a long way.

A postcard from the late 1960s illustrates the connection between CIS , the Mint, and Singapore.

An exhibition booth showcases coins from the Singapore Mint, 1970.



Philip Yeo visiting the Swiss Federal Arms Factory, 1981. Under Yeo's leadership ST was transformed from a group of defence companies into a technology-based multinational conglomerate.

While the historical record shows clearly that diversification into commercial, non-defence areas was an impulse present from the start, most insiders credit Philip Yeo, as Executive Chairman of CIS from 1979, with putting the commercialisation drive into high gear. His enthusiasm for re-engineering the group was infectious. To those who felt, rightly or wrongly, that the government-owned defence industries were too clumsy to be taken seriously in the market, Yeo's leadership signalled that the group was ready for change, and that enterprise would be rewarded. "It was a mental milestone", recalled Mr Wong Kok Siew, persuaded by Yeo's vision to leave his private sector job to head the newly set-up CDC Construction, now known as Singapore Technologies Construction. Following the restructuring of Sheng-Li which placed all the group's non-defence and industrial businesses in Singapore Technologies Industrial Corporation (STIC), Wong was appointed STIC's first President.

Yeo knew full well the difficulties of selling arms abroad (Dr Goh once introduced him as "my chief gun runner" when Yeo was Chairman of Unicorn). The economics of declining defence sales, apparent in theory to Dr Goh from the beginning, was becoming more urgent and real a prospect in 1979. "I could see that the day of reckoning was coming," said Yeo, "it was not a comforting thought. Ordnance and Aerospace, in particular, were then very dependent on Mindef for orders. The paramount question in our minds was: how do we quickly expand and diversify into non-Mindef business in order to ensure the viability of the defence industries?"

ST Mobile Aerospace Engineering (MAE), a wholly-owned subsidiary of ST Aero, is located at the Brookley Industrial Complex in Mobile, Alabama, US. Like its sister company SASCO, MAE is fully equipped to do major inspection and maintenance of commercial aircraft.

Mr Howe Yoon Chong – who took over as Defence Minister from Dr Goh in 1979, and brought along with him the keen sense for commercial operations that he had displayed in his tenure as Chairman of the Port of Singapore Authority – gave Yeo a free hand to re-engineer the companies. This Yeo did, with a vengeance.

Yeo's strategy was to retain the production functions of CIS intact, but to spin-off all its service functions, such as testing and freighting. His target was to make at least 50 percent of CIS non-defence. To this end, he took functions that he thought had commercial potential out of CIS proper and located them in separate companies. CIS was stripped down to its core armaments business, and a slew of new companies – concentrating on logistics, computer services and construction, to name just a few – were created. As he established these new enterprises, Yeo made a point of moving them out of CIS's premises altogether, so they could learn quickly to stand on their own feet and become independent, leaving the management of CIS itself to concentrate on its primary role. Yeo was confident his shake-up of CIS would allow the different entities to focus and dig deep in their respective fields of operation.

By 1987, after an in-depth review, Mindef redefined the roles and responsibilities of the group. The Singapore Defence Industries (SDI) Charter defined the group's relationship with Mindef and set the tone for its strategic direction. The charter spelt out the group's two-fold mission: contribute to Singapore's strategy of "Total Defence", as well as to its "economic prosperity, by undertaking beneficial commercial and industrial activities regionally and globally." The primary mission was still to provide technological and industrial back-up for the SAF, but it was now clear that commercialisation and diversification were the only ways to lower costs and retain skills vital to maintaining the competitiveness and efficiency of the defence industries.

In addition to engaging in core defence-related activities, the charter said, "SDI will also undertake industrial and commercial activities which have synergies with, support or extend the core defence-related activities." This would spread overhead costs, even out workloads, create synergy with existing capabilities, and in other ways, enhance the economic viability and international competitiveness of all ST operations, products and services. As Yeo noted, "diversification became a logical consequence of supporting the SAF. Singapore Technologies had to be allowed to go into export sales and into domestic non-military businesses in order to survive."

An example of such diversifications within the group was in aerospace. Two of the purely commercial companies formed in the 1990s were in the aerospace line. The group's aerospace arm, ST Aero, set up a local commercial aircraft maintenance subsidiary, ST Aviation Services Company, or SASCO, with Singapore Airlines and Japan Air Lines owning ten percent each. And in Alabama, USA, ST Aero set up ST Mobile Aerospace Engineering (MAE), which carved a niche for itself converting passenger planes into freighters, and carrying out heavy maintenance.

The EC120, a five-seater Light Helicopter, was jointly developed by ST Aero, Eurocopter of France and China National Aero-Technology Import and Export Corporation. It made its maiden flight at the Paris Air Show, 1995.

As we have seen, ST Aero had already chalked up many air-miles of experience through ST Aerospace Engineering (formerly, SAMCO). Formed in 1975 to maintain the RSAF's aircraft and equipment, it quickly moved into non-military work. When another company was formed to overhaul aircraft engines in 1977, it was set up as a joint-venture between Singapore Airlines and the defence industries.

As Quek Poh Huat noted, "Mindef provided the main contracts for these aerospace enterprises initially, but Dr Goh made it clear that we had to make a profit. The decline in Mindef workload was foreseen. We had to look overseas, including commercial airlines."

Accordingly, in the 1980s, the aerospace business took a two percent stake in Pratt & Whitney's programme to develop the PW4000 engine to power the Boeing 747-400 (the engine is also used in other aircraft such as Boeing's 767 and 777, the Airbus A300, A310 and A330)."We invested US$32 million in the venture", Lim Ming Seong recalled. "We were allowed to make parts for the engine and supply Pratt & Whitney as a single-source supplier. The parts included the blades and the vanes in the engine." "So today," Lim said proudly, "if you fly a 747-400, and if it is powered by the PW4000 engine, 58 parts in the engine come from us in Singapore. We increased our share in the risk-revenue share programme to three percent in 1994 with another investment of US$46 million."

In 1996, the group signed a letter of intent with Aviation Industries of China (AVIC), which was planning to produce a 100-seater aircraft, in partnership with a European consortium. The group was also building a helicopter, the EC120, for commercial use, together with French and Chinese partners. But the group's main business in the aviation line was squarely in maintenance and overhaul.

SASCO, for instance, derived a large part of its business from maintaining Boeing 747s. In particular, it replaced the key ribs of the plane's skeleton, from the cockpit to the first passenger door, known as Section 41, which tend to get worn out after many cycles of take-offs and landings. While Section 41 work brought a stream of older 747s to SASCO's hangar, the company also provided other maintenance services to extend the range of its business. One programme was for the modification of the 747's engine pylons, while another was to carry out 'D' checks – the industry's equivalent of a complete physical examination. Such checks and modifications are required by international aviation law, ensuring a steady stream of business for companies such as SASCO. But SASCO also offered its customers 'extras' – from repainting the exteriors of planes to refurbishing cabins with seat-back, in-flight video entertainment systems. An airline could thus send a plane to SASCO for a mandatory check-up, but also ensure that the unavoidable downtime would be put to good use, by getting various optional improvements carried out.

The wisdom of commercialisation was readily apparent. In the 1990s, most of ST Aero's profit and sales growth stemmed from its work on commercial aircraft. In 1996, while turnover in its commercial sector increased by 24 percent, its military sector only managed a marginal growth of two percent.

Another company to diversify early was ST Electronic and Engineering (ST E&E), formerly SEEL. Initially formed to provide the SAF with electronic and electrical services, ST E&E became a highly diverse electronic systems integration business. It moved aggressively into non-defence areas even as it continued to service the various arms of the SAF. The same skills that helped it integrate the command and control systems of naval boats were exploited for commercial purposes.

ST E&E won the contract to install Singapore's Mass Rapid Transit System's supervisory control and communications system. Other projects followed: building automation projects for Raffles City, Changi International Airport Terminal One, Singapore General Hospital and many other mega-projects.

As a complement to its systems integration work, ST E&E began also in the mid-1980s to develop and manufacture key components of the systems in question. Not only did this move add value to its systems work, it deepened the company's engineering focus and capabilities, and provided a huge export potential. ST E&E's wide range of products and services now include intelligent monitoring and control systems (QMACS), integrated digital electronic switches (INDEX), configurable operator consoles (CONOCO) for military and paramilitary command and control applications, automatic carpark management systems (AUTOPARC) and computerised toll management systems (AUTOLL).

Oh Chong Ho

Oh graduated from NUS in 1981 and started his career at Texas Instruments as a process engineer. Then in 1982, he joined Keppel Shipyard. Oh was sent to Japan for design training, and when he returned, worked as a design and project engineer at the shipyard's facilities at Pulau Hantu and Tuas, and on industrial projects with Keppel Industrial Engineering. Oh joined Singapore Aerospace Manufacturing in 1986 as a design engineer. He headed the Engineering Department in 1988, and from 1989 to '94 headed, in succession, the Quality, Sales and Marketing, as well as the Business Development departments. He became the Business Unit Manager in 1994, and General Manager in 1997. Oh has a Bachelor's and a Master's, both in Mechanical Engineering, from NUS, and an MBA from NTU.

SASCO's operating hangar is large enough to park two Boeing 747s, and is equipped with a complete docking system that provides easy access to all sections of the aircraft.

Persevering Through Adversity: The SASCO Story

Knowing what it takes to succeed is sometimes synonymous with knowing how to survive adversity. This is particularly true in industries that are prone to periodic sharp downturns. ST Aviation Services Company (SASCO) is in one such industry.

SASCO occupies a cavernous two-bay hangar in Upper Changi Road, a stone's throw from Singapore's Changi Airport, one of the busiest hubs in the world. The hangar is so huge it can, at any one time, accommodate two Boeing 747s as well as a smaller plane in-between.

The 747 jumbo jets in the hangar are a sight to see. Resting on stout yellow tripods, not on wheels, the planes are shorn of the glamour that exudes from their cousins which fly in and out of the airport. Their paint is stripped; their nose cones are removed for safe storage to prevent damage to the delicate radar equipment within; and their panels are removed, exposing the skeletal structures underneath. Multi-tiered platforms hug their sides, allowing workers to walk alongside the fuselage, like Lilliputians swarming a beached Gulliver. Flat faced, naked, and exposed, one can see the jumbos for what they are: massive metal ships that should, but for some miracle of aeronautic science, be firmly on the ground.

The people at SASCO dedicate themselves to making sure that travellers who enter the bowels of these metal beasts continue to take for granted the feat of flight, and focus instead on the service, food and in-flight movie.

Thanks to SASCO, passengers of 57 Boeing 747s around the world do not have to worry that after many cycles of take-offs and landings, the front section of the plane begins to show signs of fatigue. The key ribs of the plane's skeleton, from the cockpit to the first passenger door, known as Section 41, are replaced. The parts come in large wooden chests from Boeing, and the procedure is fairly routine. But SASCO has gained a reputation for fast turnaround time and quality service. It can complete Section 41 work in a record 42 days, compared with the industry average of about 50.

But all this might have come to an end in 1994, when there was a worldwide downturn in the aircraft maintenance industry. The industry as a whole had anticipated the downturn after the 1991 Gulf War, but the downturn took its toll nevertheless. SASCO was badly hit. It reported a loss of more than $17 million in the first six months of 1995, and its workforce was cut by 20 percent.

But the company survived. And not only did it hang tough through the grim times, it even took a calculated risk in the midst of its troubles. In 1994, right smack in the middle of adversity, SASCO commissioned the building of its Upper Changi Road hangar for $65 million.

To persevere, with confidence and courage, right through the hard times, was the chief, but not the only, lesson that SASCO learned in that period. As Mr Wee Siew Kim, the 30-something President of SASCO, noted, the company learned also to be pragmatic in dealing with the fluctuations in the industry.

"You must be flexible if you want to weather bad times in business. The 1994 downturn forced us to look into all our productivity indices and squeeze out more at the margins: better purchasing processes, more streamlined operations, even faster turnaround than the industry record we ourselves held. We also developed better marketing strategies, such as offering airlines a co-marketing deal with our sister company, Mobile Aerospace Engineering in Alabama. But the most important factor in our survival was unity in adversity. It was primarily because of our workforce that we rode out this really rough patch. Everyone, management as well as workers, accepted a freeze on bonuses and salary adjustments. Our people kept the faith."

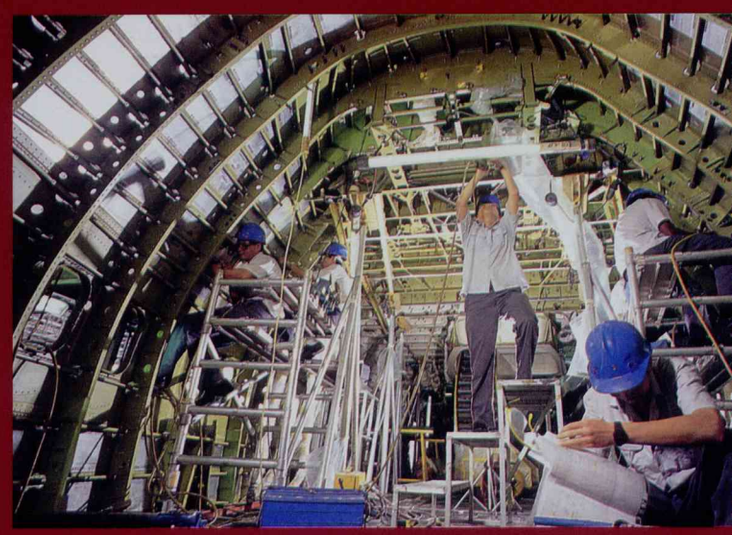
Such stamina had its roots in the three preceding good years, from SASCO's launch in July 1990 to the end of 1993. With Japan Airlines and Singapore Airlines each having a ten percent share in the venture, the company was able to benefit from the worldwide demand for Section 41 modifications. But SASCO also used that time to acquire good habits, including a strong work ethic and a devotion to quality.

By 1996, SASCO had recovered from the downturn. Its turnover increased by 39 percent that year, to $67 million. Indeed, ST Aero as a whole, of which SASCO is a part, registered an impressive turnaround in 1996, with it net earnings surging to $27.8 million, compared to a loss of $48.3 million the year before.

Backed by ST Aero's international reach, SASCO is now positioned to be a world player with a healthy client base of top airlines. Wee is determined that SASCO will grow in size and breadth. Its first priority, he said, is to keep improving quality while maintaining competitive pricing, even as competition in the industry increases. Next, is to increase the range of aircraft types that SASCO can handle by making investments in more sophisticated test sets and instruments. Similar priorities saw SASCO through the downturn, and there is no reason to believe that what served it well on the downturn, will not serve it well on the upturn.

SASCO knows that the best way to meet the future is to continue working on the fundamentals through the good times as well as bad.

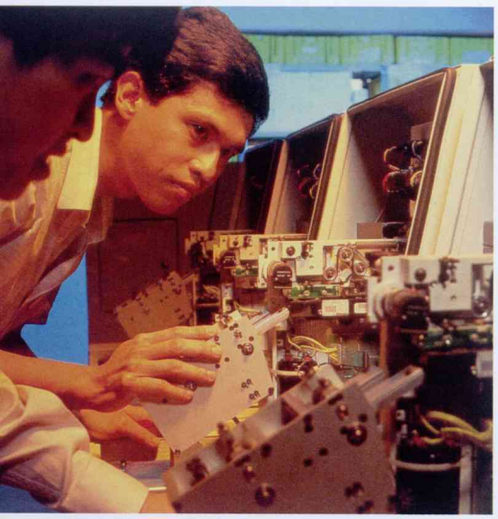
A Boeing 747 undergoing Section 41 work.




SASCO
Singapore Aviation Services Company
JAL
JA8130
Japan Airlines
BOEING 747

Previous Spread
ST Aviation Services Co Pte Ltd (SASCO), formed in 1990, does a wide range of maintenance, repairs and modifications of aircraft.

Opposite
Designing and building ships may be more glamorous, but the business of maintenance and refurbishment are equally important to ST Shipbuilding.



ST E&E provides products and services for a wide range of applications, including both military and commercial vessels and aircraft, as well as building automation and mass transit systems.

Like the diversity of its products, the history of ST E&E is itself a symbol of the transformative effects of diversification. It was first formed as a 'naval' company in 1969 out of the old weapons and electronics workshops the British had left behind in the Naval Base. But in the early 1980s, because of the nature of its work, the 'naval' company became an 'aerospace' company, and it was made a subsidiary of Singapore Technologies Aerospace. And in 1989, the 'aerospace' company was transferred out of the aerospace sector of ST altogether, and was made a part of ST's industrial sector (STIC), in preparation for public listing in July 1991.

As this progression from 'naval' to 'aerospace' to 'industrial' shows, the diversification of the defence companies had become so complex by the late 1980s that the old boundaries were rendered increasingly porous, and sometimes meaningless. Naval electronics could also be aerospace electronics; military business could also be non-military business; defence systems integration could also be non-defence systems integration.

But the commercialisation process was not always a smooth ride. All of the group's businesses had their share of painful experiences. The aerospace arm, for example, was hit in 1995 by the weak US dollar and a worldwide glut in aircraft maintenance facilities. In the first six months of that year, SASCO reported a loss of more than $17 million, comprising a write-down of inventory of $8 million and current operating loss of $9 million. The company was restructured, and it started marketing its services more aggressively worldwide, with the help of the ST group.

Shipbuilding's experience of such sudden changes in fortune came even earlier. One bad patch was encountered in 1977. In that year, SSE (as ST Shipbuilding was then called), after protracted and hard negotiations, and amidst keen competition, won a contract from a consortium of German owners to build ten container vessels. It was calculated to be a break even contract, but it was nevertheless a cause for celebration, as Kua Hong Pak, a former Managing Director of SSE, recalled.

"It provided the much-needed jobs for the shipyard to recover its overheads as its order book was running down during a period which saw the shipbuilding industry experience a worldwide slump. However, we soon ran into problems of cost-overruns for the project, technical problems in the construction of the vessels, and a difficult and demanding group of shipowners. We ran into penalties for late deliveries, and coordination problems relating to delays in the delivery of materials and equipment by different suppliers. This was compounded by frequent changes at the senior management level. The expatriate general manager developed health problems and resigned on medical grounds.

ST Shipbuilding builds various commercial vessels, including LPG tankers, container vessels, high speed passenger ferries and offshore supply vessels.The company is also capable of an extensive range of shiprepair work on both commercial and military vessels – including ship conversion, refurbishment, modernisation, retrofitting, rebuilding and upgrading.

"Things came to a head in 1978-79, when losses incurred on the project became so huge that the company was on the verge of collapse and its future viability called into question. Our main banker, which had a first debenture charge on our assets, decided to call in their loan, and in the event of default, threatened to foreclose on the company." A rescue operation had to be mounted, entailing Sheng-Li pooling resources from its more liquid subsidiaries to save SSE.

To cut down losses, the shipyard also negotiated with the German owners in 1979 for cancellation of the last four vessels. These were then built and sold to other buyers. "SSE adopted the marketing strategy of repackaging the container vessels by reducing their sophistication and thus their purchase price to make them more attractive to potential buyers." For Kua, the lesson was that although SSE had the technical capability to build the mini-container vessels, the company's organisation, structure and management were ill-equipped to cope with a project of that magnitude.

By the mid-1980s, virtually every business unit in the defence industries was pursuing commercial diversification. But as a later audit of the defence industries, known within ST as the 'Monitor Study', would note, the record was not always good. For one thing, the defence companies had neglected business development.

Although the SAF was not obliged to buy from them, the military side of their business was clearly a more straightforward proposition than the commercial side. The defence industries had been geared towards satisfying Mindef needs, and hence were vertically integrated to deliver a broad range of products and services to a single local buyer. The commercial side of their business, however, was a different proposition. Here, they had to contend with the multiple and widely differing forces of the market-place. They were not always well-prepared for this challenge.

Wong Kok Siew defined the central weakness of the defence companies in this period thus: "It was a challenge to find people with the right commercial mindset. Our people were not oriented to serving a variety of clients, after having served one main client for so long. They also needed the mindset to make timely, quick decisions, and to compete with many other suppliers."

Another weakness of the group in the 1980s was its misunderstanding of the process of acquiring high-end technology. As Ms Ho Ching, who became President and CEO of the group in April 1997, recalled, "the group thought they could start a venture capital outfit for technology acquisition. They made investments for strategic reasons."

In time, however, the group realised that technology acquisition and transfer required not only a well-chosen outside source to exploit but also an appropriate receptacle within ST to receive and develop the technology. If ST's own companies were not ready, in terms of their technological, managerial or marketing capability, there would

be no technology transfer, regardless of how sound the new acquisition seemed on paper.

Accordingly, in 1988, the group decided that venture investment decisions had to be made on the basis of anticipated financial returns. "If there is technology transfer, that will be the cream", Ho Ching explained. This approach to making investment decisions introduced a more disciplined regime in the group's strategic planning.

Dr Goh Keng Swee gave a similar reading of the group's problems in the 1980s in a paper he presented at an international conference in 1992. He recalled that when ST companies first ventured into "high technology enterprises not related to weapons production, they fared badly. Losses were reported in foreign newspapers to have exceeded US$200 million. The real figure is nearer half of that, still a large sum. The cause of failure was not in production but in marketing in foreign markets. The promoters of these ventures underestimated the difficulties in finding customers." Dr Goh went on to report that the government had ordered a change of leadership "to salvage, sell or close" the "loss-making enterprises". This was "in line with the firm policy of not subsidising them or their subsidiaries". The losses sustained in these ventures, Dr Goh noted, were absorbed by other ventures which were profitable – proving, perhaps, the wisdom of having many irons in the fire.

Tan Pheng Hock

Soon after completing his NS, Tan joined SSE (now ST Shipbuilding) in 1981 as a staff engineer. Over the years Tan has held various posts in the company, including Technical Services Manager and Deputy Project Director. Tan is now Executive Vice President, Yard and Business Development. He is responsible for marketing shiprepair services as well as new ships, overseeing all shipyard operations,and diversifying into land-based engineering business. Tan has a BSc in Marine Engineering from the University of Surrey, UK, and an MSc in Management from Stanford University, US.

An Automated Guided Vehicle (AGV) at work in Singapore's busy harbour. The AGV is a project of CEI Technologies, an ST subsidiary.


PEARL GRACE
Singapore
TechnoLogies

Previous Spread
The two floating docks at ST Shipbuilding's Tuas shipyard are capable of handling repair jobs on vessels as large as 70,000 DWT, and building vessels as large as 30,000 DWT.

Ooi Ling Heong

Ooi, now Senior Vice President, International Marketing, ST Aero, joined the ST group in 1977 as a Senior Service Engineer in ST E&E. His early training was as a Licensed Aircraft Engineer, under the auspices of the Colombo Plan Scholarships, at Qantas Airways, Sydney. He holds a Diploma in Management Studies and Marketing from the Singapore Institute of Management and the Institute of Marketing, UK; he also has an MBA from the Wharton School, University of Pennsylvania, US, and has also completed Stanford University's Programme in the Humanities. Asked why he stayed with ST for 20 years, Ooi said , "ST's been like a good wine to me, each passing year simply adds to its excellent vintage."

The Meat Shop, the retail arm of Singapore Food Industries. SFI was originally set up to provide a very important service to the SAF – feed it! If, as Napoleon once said, "an army marches on its stomach", SFI can be said to provide the requisite calories for marching. The company has since expanded into commercial enterprises, including pig farms, chilled ready meals, and hotel and supermarket supply.

Even when diversification was commercially successful, there were pressures of a different sort. In the 1980s, government-linked companies (GLCs) were routinely accused of crowding out small- and medium-sized local enterprises. ST was not spared from criticism. In late 1991, when an STIC subsidiary, Singapore Food Industries, merged with a local food company that was already, among other things, Singapore's largest roast duck supplier, the development drew sharp criticism from local businessmen who mistakenly asked why a giant GLC should enter the domain of the humble hawker. SFI's roast duck became such a *cause célèbre* that the matter even surfaced in Parliament as a subject of debate.

As Wong Kok Siew explained, the view that ST had muscled-in on the humble hawker was a distortion of reality. SFI by then had built up a very large cold room and distribution capability, and was looking to expand regionally. "Now, there's this company called LM Food, set up by the Loy family. Like us, the Loys saw the potential of the regional market. But as a $30 million company with limited resources, they couldn't expand. So they did what was obvious: they looked around and said to us, 'hey, if we have the same dreams, why don't we get together and then, hopefully, make all our dreams come true?' So we merged the two companies.

"And it was LM that had seen an opportunity in production-line roasting under hygienic conditions. They had been in the business for a long time, and when we merged, supplying roast duck fortuitously came under the umbrella of SFI. The trouble is, this story behind the whole roast duck

thing did not come out into the open, and I must blame ourselves because we didn't go out and explain what was happening." The last was a mistake that ST took pains to avoid in the future.

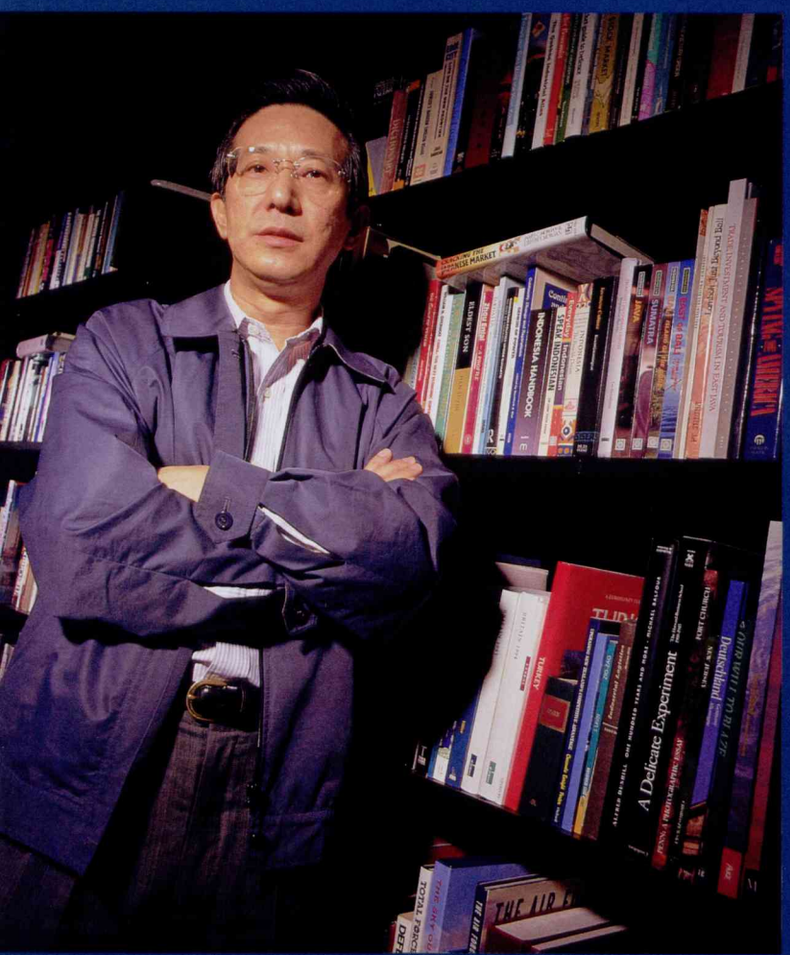
By 1990, ST no longer had any illusions about the difficulties and risks involved in commercial diversification. Even when the non-defence businesses were offshoots of established defence activities that the group was technologically competent in, it was clear that additional skills were called for, in management and marketing. Change was inevitable, but that did not mean that it was going to be painless.

Equally, however, the rewards – indeed, the imperatives – of diversification were clear. Growth in the 1980s had come mainly from the non-defence area, and this was where the future lay. As Ho Ching noted: "More and more, we saw that the businesses we grew had to make sense in their own right, and need not necessarily be related to defence at all." The link to defence would remain – emotionally, structurally and technologically – but the umbilical cord was severed.

More to the point, a 'What next?' mentality had taken root in ST, and propelled the group onwards and outwards. It knew it had to take risks to reap rewards. Hence, well before the 1980s came to an end, the group was mentally prepared for the next major stage in its evolution: its entry into the brave new world of semiconductors. The risks would be greater than in any other venture the group had previously undertaken.

Process equipment in the diffusion area of a CSM fab. Vertical furnaces are used to grow layers of oxide, poly or nitride onto the silicon wafers used in semiconductor fabrication.

The Way of the Maverick



Long-time ST insiders say their company has been through three phases: before Philip's time, during Philip's time and after Philip's time. President and CEO Ho Ching put it even more starkly: "The personality of this company is defined by the personality of Philip Yeo."

Another in the group remarked that Yeo "was not only a boss you worked for, but also a boss who worked for you." That, the colleague said, is one reason why working with Yeo was so rewarding an experience. "He was more interested in people than in institutions."

Yeo was educated at the University of Toronto, the University of Singapore, and Harvard University. He joined the Singapore Administrative Service in 1970, and served in various capacities in Mindef, including as Permanent Secretary, before assuming his current appointment as Chairman of the Economic Development Board in 1986.

Yeo's association with ST began when it was primarily a defence-related group. He has at different times run CIS, ST Shipbuilding, Unicorn, STIC and STV, and served on the boards of various other ST entities. He was the moving spirit behind the early diversification of the defence companies into non-defence areas, and later, ST's expansion into the region. He was appointed Director of Sheng-Li in July 1980, and when an Executive Committee was formed in July 1987, became Exco Chairman. Yeo relinquished directorship of ST in April 1994.

Yeo has received numerous honours and awards, including the Public Administration Medal (Silver) in 1974, the Public Administration Medal (Gold) in 1982 and the Meritorious Service Medal in 1991. In 1994, he received the Bintang Jasa Utama, the highest civilian honour the Indonesian government can confer on a non-citizen, for his contribution to bilateral relations between Indonesia and Singapore; and in 1996, he was conferred the Ordre National de Mérite by the French government, for enhancing relations between France and Singapore.

In person, Yeo is animated, friendly, witty and dynamic. His 'live-wire'

personality, so at odds with the popular image of the civil servant mandarin as a tight-lipped and rigid creature, has to be experienced directly to be appreciated.

Something of the force of his personality, nevertheless, comes through in the following excerpts from an interview he granted for this book. As they say in the newspaper trade, he makes for superb copy. There is no mistaking the fact that Philip Yeo is altogether inimitable, *sui generis*.

On why ST diversified away from defence
The Armed Forces is a very small customer, it's finite. And exporting armaments is not easy. It's a tough business being a gun runner for the government of Singapore, selling weapons without the help of subsidies, against the French, the Chinese, the Germans. It's very tough.

I felt that it was not where our future lay. Of course, it was important to build up our defence capabilities. But ST couldn't have lived on that alone. In fact, defence wouldn't have covered our basic bread and butter. ST had to be allowed to go into export sales and into domestic non-military businesses in order to survive.

But although the diversification was not Mindef-driven, we were mindful that civilian technologies could also be used for the benefit of the military. For example, ST Auto uses such technologies as automatic transmission and fuel-injection systems, which can be applied to upgrade the SAF's armoured vehicles. When I left the ST group in 1994, I left with great satisfaction that it had set out on the right diversification route, without compromising the SAF's requirements.

On whether ST's diversification led to a loss of focus
The word 'focus' is a very dangerous word. If I had just focused on the business of Chartered Industries – if I had just used one pair of eyes rather than multiple pairs of eyes, and not diversified – there would have been no ST today. My approach in ST was one of multiple focus. If we had stuck to just one thing, we would have run into trouble.

Look at Canon. You may think Canon is a camera company, but Canon's camera business is less than ten percent of its total business. Canon is in semiconductors, copiers, printers, and many other things. Companies which just focused on cameras, like Rollei, disappeared.

On why he decided to regionalise ST's activities
I felt that Singaporean companies could not just remain in Singapore. We had to do something beyond Singapore. ST was the first local company to go regional without anybody knowing it. We had offices in Kuala Lumpur, Hong Kong, and Bangkok, at a time when all the GLCs in Singapore just stayed at home – there were no official guidelines or blessings given to do overseas work. People would say to me: "What are you doing, a government-owned company, running around all over the place?" We just ignored them and carried on.

So we started regionalisation long before anybody talked about it. To us it wasn't regionalisation, it was business – we had to find places where we could do lower cost assembly, take advantage of cheaper land, and so on.

On why STIC was used to build industrial parks

There was no other company I could talk to. Keppel Corporation wasn't in such business, JTC had no commercial experience other than in Singapore, and the private sector had no guts for a long-term project like this. I estimated that it would be five to seven years before we would make money in Batam. The typical private construction firm wants to build housing, sell it, and move on. With an industrial park, you can't do that. You have to also provide services like power, other utilities, housing, etc, on an ongoing basis. You have to be patient, listen to clients' day-to-day problems and take care of them. Like I always say, it's easy to be a father, but much harder to be a mother.

So why STIC? Because there was no choice. I was its Chairman, and since I came up with the idea of building industrial parks, I used STIC as a vehicle.

On leadership, and his own style of operation

I sit down and decide what to do and just do it – like the Nike advertisement, "Just do it". I'm not one of those people who believe in consensus. If I'm the Chairman, and I think the company has to go somewhere, I say to my staff: "Let's go". A leader must have a vision, a dream and a plan of action. He may have a good number two person to help implement things, but the leader must have a dream. Otherwise he can never be number one. Even a chief monk must have a dream – to make his monastery the best in the region, or whatever. That's how I view leadership.

But I depended on key individuals to run businesses, because I created about 40 companies and I could not run them all. So my approach was to find good people and back them. Those who were doing well, I left them alone. Those who ran into trouble, I jumped in and helped them. So the main reason for ST's success was not myself. We had many good people at the working level. The credit goes to all these people. I was also lucky to have had good bosses – Dr Goh Keng Swee, Mr Howe Yoon Chong and BG Lee Hsien Loong.

On the effectiveness of business plans

Any fool can draw up a plan. A computer can generate a plan. But picking the right plan and implementing it, that's the hard part, that's how a guy learns. I had no business plan for Batam, or for ST Computer Systems and Services, or for Singapore Technologies Construction. I had a dream of what to do, and I planned along the way and implemented along the way.

So whenever someone comes up with a business plan, I am the greatest sceptic. I never do it that way. I plan on my feet, with my guts.

On ST's corporate culture and venture spirit

The corporate culture during my time was: if you had a good idea, you could walk into my office. If it sounded logical, I would say "OK, go with it, form your company, call it whatever you like, and start". We didn't call it innovation or entrepreneurship. We just did it. This venture spirit was very important. I knew, of course, that out of every three ventures, two may fail and one may succeed. If I insisted that all three must make money, I would be a nervous wreck – and I would never do anything!

One advantage of being a GLC in Singapore is that you are not stifled. The government doesn't have a GLC plan specifying that they will do this or that – thank goodness. The government owns, but it doesn't sterilise everything. The chairman or CEO of a GLC has a lot of freedom. He has more authority than the CEOs of some multinationals here. In a multinational, for every dollar you spend, you have to go to headquarters for approval. Glorified title, well paid, but low authority level.

When I was running ST, if my managers came to me for anything less than $10 million, I would say to them, "don't waste my time; you go and take care of it; what the hell did I hire you for?" That was the spirit in ST. I'm not sure whether it applied in the other GLCs. The others were more established, more mature.

So our managers had responsibility and authority. They were underpaid, sure, but they were doing a meaningful job. They enjoyed the freedom and the opportunity to run a real business. They got psychological rewards, not monetary ones. If they were only interested in money, many of them would have left long ago. But they had something they could not find in other companies – the freedom to do things.

It was fun.

Philip Yeo, in his youthful days, launching the first Quality Control Campaign in 1977.

If you can keep your head when those around you
are losing theirs and blaming it on you;

If you can trust yourself when all men doubt you,
but make allowance for their doubting too...

If you can meet with triumph and disaster
and treat those two impostors just the same;

If you can make one heap of all your winnings
and risk it all on one turn of pitch and toss;

And lose, and start again at your beginnings
and never breathe a word about your loss;

If you can bear to hear the words you've spoken
twisted by knaves to make a trap for fools;

Or see the things you gave your life to, broken,
and stoop and build 'em up again with worn out tools...

Then yours is the world and everything that's in it....

Rudyard Kipling

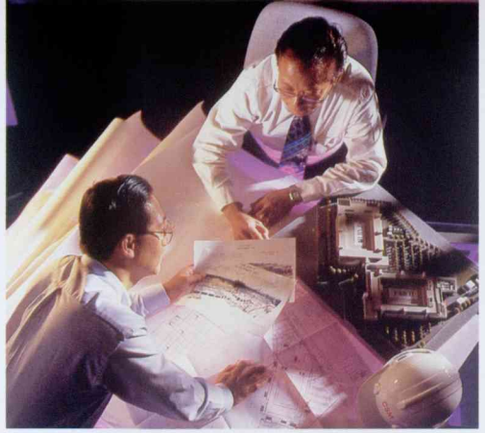
Opposite Page
A technician at a probing station; sophisticated tools are used to conduct failure analyses of semiconductors.

The Saga of CSM: ST's Finest Hour

"If I ever had a billion dollars, and had to choose between putting it in a trust fund and putting it in a semiconductor facility, there's no question what I would do", said Mr Pao Ning Yu, General Manager of ST subsidiary TriTech Microelectronics. Pao had lived through the traumas, the near-death experiences and ultimately, the heady triumphs, of CSM. "I'd go for the trust fund any day", he said.

It's easy to see his point. Who, after all, would want to get into a business where you need a minimum of US$1 billion just to set up shop; where, moreover, you need to keep investing that kind of money for tomorrow – not only to grow, but to stay alive; where you have to plan not just for the next twelve months but for the next five and ten years; where the market jumps like a yo-yo and is virtually impossible to forecast; where you have to establish a global marketing network; and where skills are scarce and you need to hire more than 500 world class engineers and 500 technicians for every plant you build?

CSM's wafer fabrication plant in Woodlands, at the northern tip of Singapore, is a sprawling building. The first thing you do when you get past reception is to slip special lint-free covers over your shoes. Semiconductors and dust don't mix, and at CSM, they take no chances. The heart of the facility where the chips are actually manufactured is a 70,000 sq ft 'clean room'.



CSM management discussing plans for a new fab.

In the cleanest of surgical operating theatres, the dust-particle count in the air is about 10,000 per cubic foot. In CSM's clean room, it is 100. But the critical processes involved in actual wafer production take place inside hermetically sealed one-cubic-foot boxes called 'pods', where the particle count is barely one.

As wafers go through successive stages of production, they are moved by computer-controlled robotic arms. The entire operation is so intensely automated that errors are virtually eliminated. CSM's 'line yield' – the number, that is, of wafers that come out of the production line as they are intended to, relative to the number that go into it – is among the highest in the industry.

This particular fabrication plant – Fab 2, they call it – is the latest of CSM's semiconductor facilities, completed in less than 16 months in 1995. A little distance away, the cranes and bulldozers are finishing work on Fab 3, which is expected to start production in late 1997 with a maximum capacity to produce about 40,000 8-inch wafers a month. After that, there's going to be a Fab 4 and a Fab 5. Each will cost at least $2.5 billion.

But all these might never have happened. Almost didn't.

The story of ST's diversification into the semiconductor business – arguably, its boldest diversification yet – has its origins in the early 1980s. As mentioned earlier, Philip Yeo had taken over as Chairman of CIS. Besides spinning off a number of functional service areas within CIS into independent companies, he also decided to create a new company to go into production (as opposed to merely servicing) in the area of electronics. This company was Chartered Electronics Industries (CEI), born in 1981.

CEI was not an instant success. While it was strong on engineering, it had virtually no marketing capabilities. Reflecting on those early days, Yeo recalled wryly: "It's wonderful to have great engineers, you know. Engineers like to create version one, version two, version three. But they don't understand the market. They think customers will come to their door and buy from there. Also, they never want to release a product until they have perfected the wretched thing." Engineers make lousy salesmen, he added. "A good salesman says to a customer 'this is the best model available today'. But an engineer-salesman is a disaster. He will tell the customer: 'don't buy this model; a better model will be coming out tomorrow'." That, said Yeo, was the problem with CEI in the early 1980s. "We had fantastic engineers, but we couldn't sell. So we lost money, until we changed our attitude." They did.

Other than lessons about marketing, the early failures of CEI yielded something else that proved to be invaluable: a strong core of engineers who had been through the trial and error process of learning to build semiconductors. And so, when a Swiss-American computer engineer, the late Dr Jean Hoerni, suggested to Yeo that Singapore should go into full-fledged semiconductor manufacturing, he found a receptive listener. One of the founders of the chip-making giant, Fairchild, in the 1970s, Hoerni was a legend in the industry. He was the first to suggest that quartz crystals be used together with chips in watches,

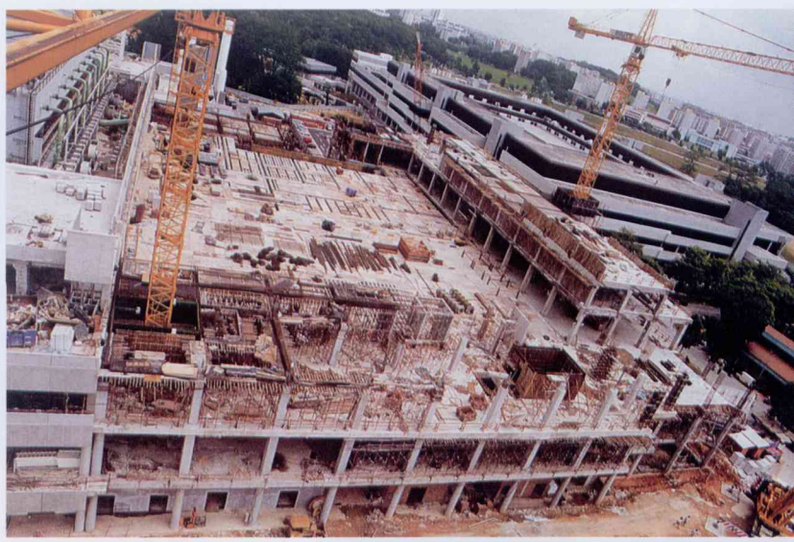
and had approached watchmakers in his native Switzerland with the idea, but they turned him away. He took the idea to the Japanese, instead, who saw its potential, and today they are the world's leading watchmakers.

Hoerni was definitely a man to listen to, and Yeo saw at once that the potential rewards of manufacturing semiconductors could be fantastic. Computer chips were destined to be an integral part of thousands of devices – from watches to cars, from televisions and toasters to spaceships. And there was, of course, the PC revolution: computers were well on the way to becoming, as Tohru Moto-Oka, the computer scientist who headed Japan's Fifth Generation computer project, put it, "society's central nervous system".

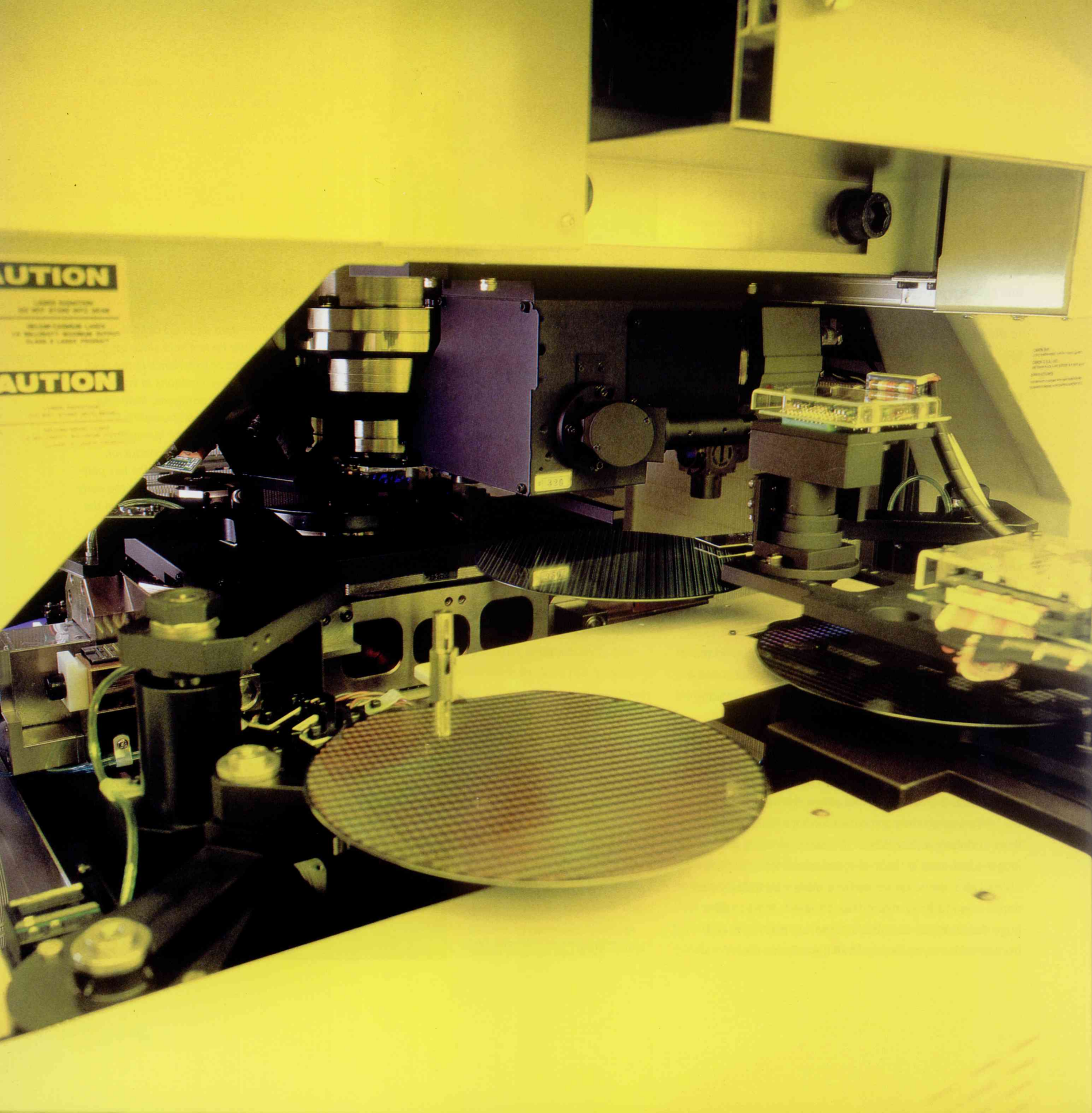
Wafer fabrication is the highest productivity segment of the semiconductor business. In good times, the value-added per worker can hit as much as US$500,000 to $600,000 a year, compared to less than US$100,000 a year for semiconductor assembly and testing. On the other hand, manufacturing semiconductors is a high-investment, high-risk, long-term business. Violently cyclical and fiercely competitive, it is taxing not only on resources, but also on resilience and creativity. It has a high mortality rate, and the losses, when they come, can run into hundreds of millions of dollars a year. When ST was considering getting into the business in the mid-1980s, small fabs, such as CSM's Fab 1, could be set up for a mere – by today's standards – $50 to $100 million; nevertheless, it was still a huge decision, the sort that a corporate planner is confronted with maybe two or three times in his life.

Tan Bock Seng

Tan is President and CEO of CSM, an appointment he has held since 1993. With 26 years of experience in the field, Tan has held key positions in various multinational corporations, including Fairchild and Texas Instruments. Prior to joining CSM, he was the Managing Director of National Semiconductor, Singapore. Tan was among the key players in the turnaround of CSM in the early 1990s to make it a star performer in the ST group in 1995.



Fab 3 under construction. A semiconductor wafer fabrication plant is called a 'Fab'. CSM's first Fab cost upwards of S$300 million, and was set up in 1988. Fab 2 cost S$1.3 billion and Fab 3, due for completion in late 1997, will cost S$1.8 billion. Other Fabs have been planned, the costs of which are estimated to be at least S$2.5 billion each. Fab 3 will have about 90,000 sq ft of cleanroom space and will produce about 40,000 eight-inch wafers a month.


AUTION
AUTION

Opposite Page
This step and repeat, precision lithography tool is used to transfer the tiny circuit onto the wafer.

Yeo was such a planner. He said yes to Hoerni. The group *would* venture into the mainstream of semiconductor manufacturing. In 1986, Hoerni was hired as an engineering consultant to ST (and later, in 1989, became a consultant to CSM); and a task force, led by Mr Lee Kheng Nam, President of Vertex Investments, an ST subsidiary, was established to study the feasibility of the project.

One of the first things the task force had to do was to identify suitable technology partners. Ideally, what Lee and his task force were looking for were companies with renowned names and cutting-edge design capabilities, as well as a capacity to absorb the output of the proposed semiconductor manufacturing plant. Three potential partners were initially identified, but two wanted a lot of money, so ST settled on Sierra Semiconductor, then a small startup formed by a team that had once worked for National Semiconductor (NS).

Because of Sierra's size, however, Yeo wanted an established name to come in as well, and waited one year before launching the project. Meanwhile, eight engineers were drafted from within the CIS group, including CEI and a small chip design company called Chartered Telmos, and some 80 more were hired from elsewhere, of which 20 were integrated circuit designers. These engineers were sent for training at Universal Semiconductor initially, and then to Sierra when Sierra agreed to become a partner in the joint-venture.

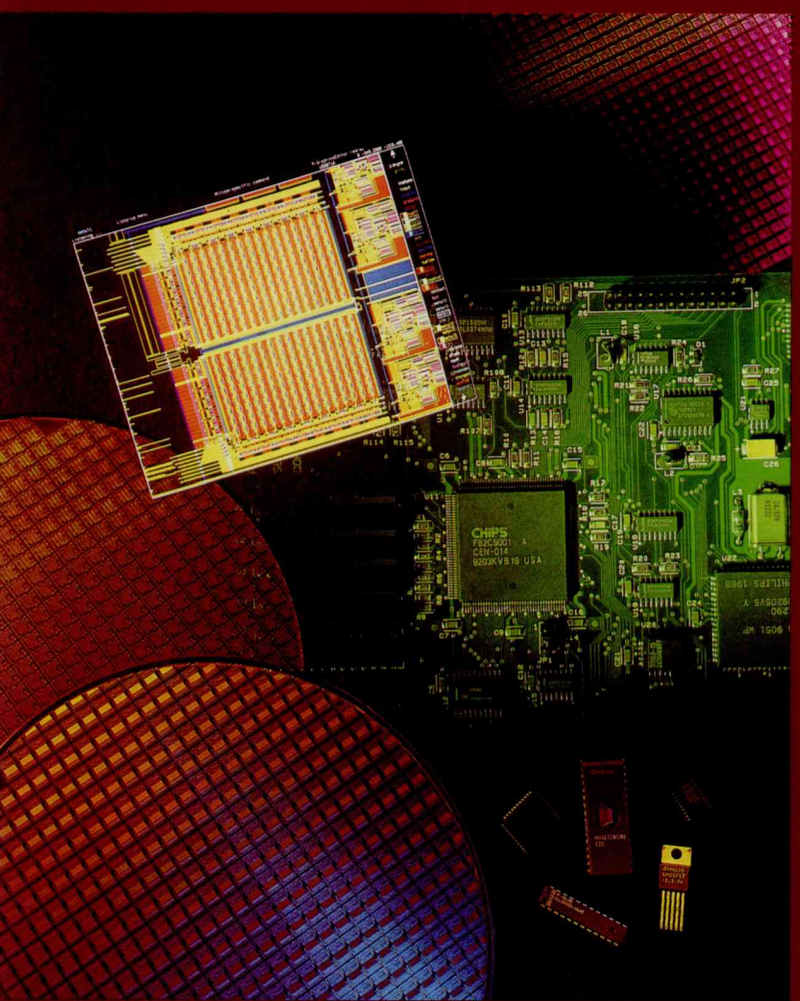
Within a year, Lee's task force, with Hoerni's help, found the big name they were looking for – National Semiconductor, a long established name in the industry. It was an especially welcome entrant into the joint-venture because its technology and culture were compatible with Sierra's, and the two companies had close links.

On the 16th of November 1987, the three-way partnership of CIS, Sierra and National Semiconductor took form as Chartered Semiconductor (CS). The deal was that Sierra would share its technological expertise with CS, and also absorb at least 60 percent of the plant's semiconductor wafers which it would sell under its own brand name, while National would provide longer term technical support and also take up 30 percent of the output.

On paper, the joint-venture looked good. CS had the benefit of tested and established technology, and did not have to reinvent the wheel, so to speak. As a captive producer, it did not have to worry much about marketing. Having a solid company like National on board provided additional technological security. With the industry riding high, return on equity for the venture was estimated at around 30 percent a year and projected to go up from there.

By the end of 1988, the venture had taken off. Engineers, sent to Sierra and elsewhere for training, had returned; construction work on a factory in Singapore's Science Park was completed in December 1988; and in the following month, equipment was moved into the factory. The factory, Fab 1, was completed in a mere 14 months – an industry record at the time – and the first wafers rolled off its production line in March 1989.

The ABC of Semiconductors



Computers perform specific functions because, somehow, they are instructed to do so. Those instructions are issued in a language called the binary code, which is expressed in a series of ones and zeros. Thus, to give a simplified example, the letter X on the keyboard could be represented by 00101, the letter Y by 10101, and the letter Z by 11101. Each key has its own unique binary configuration. In order for the computer to do its work, however, something within the computer has to be able to transmit an instruction that a specific key has been pressed, and that a letter of the alphabet, or a number, or a squiggle, or whatever, should appear on the screen. What transmits this instruction is something called a transistor.

This device – one of the pathbreaking inventions of the 1950s – functions as a digital switch. By switching electrical signals off and on (corresponding to 0 and 1 respectively), it tells the computer which binary configuration has been activated. Thus, if the key X is pressed on a keyboard, the transistor will transmit the following electrical signals: 'off', 'off', 'on', 'off', 'on' (corresponding to 00101), and an 'X' will promptly appear on the computer screen. As this sentence is being written, thousands of electrical signals flashed by transistors will tell the writer's computer what to do, and words and punctuations will appear on the computer's monitor. (If there are errors, they are mine and not the komputer's.)

In order to function, a computer today needs hundreds of millions of transistors. How can so many be accommodated? Initially, transistors were made of a light metal called germanium. But in 1958, an engineer from Texas Instruments named Jack Kilby pioneered the idea of etching transistors in the form of tiny wires placed side by side onto a substance called silicon. That triggered one of the greatest revolutions in the computer industry.

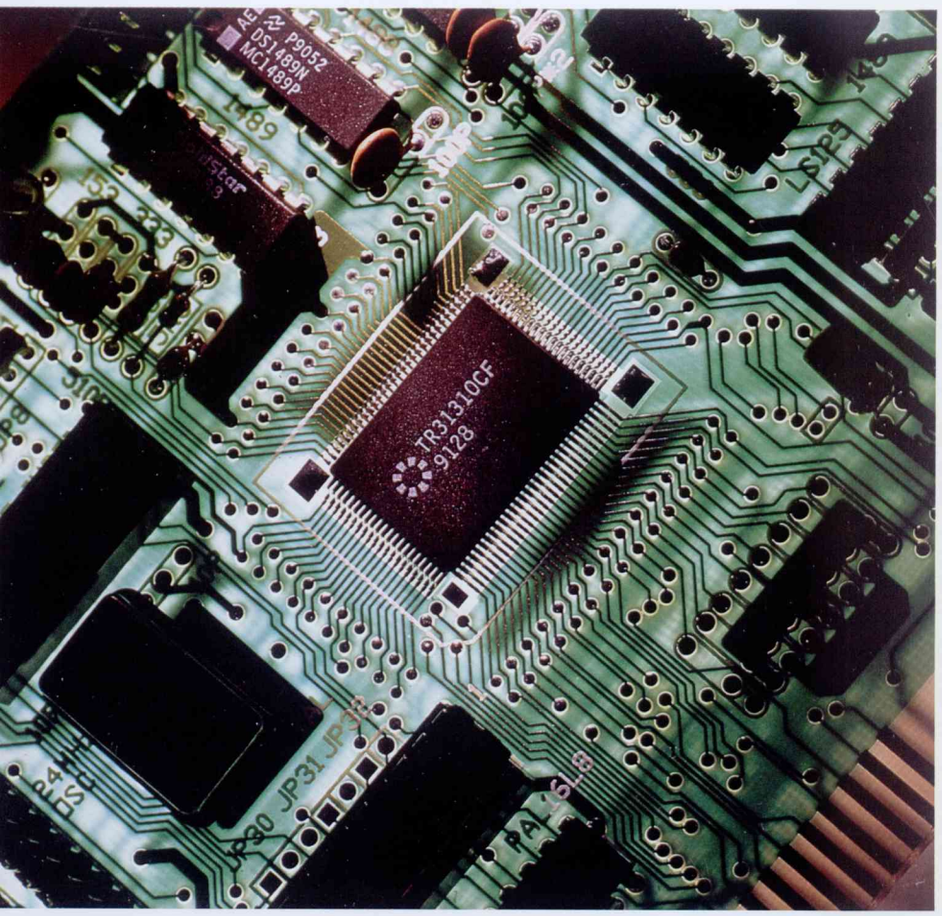
The advantage of silicon is that it is highly durable. But the greatest thing about it is that it is derived from one of the most common substances on earth, silicon oxide – sand! If you take pure sand and remove its oxygen content, you get pure silicon. Dr Kilby discovered that this was the

magic material needed to make transistors. Not only could the material conduct electricity, the amount it conducted could be closely controlled. Only one little extra step remained to complete the magic: some impurities had to be added to pure silicon to make it a conductor. And thus, these devices came to be called 'semi'-conductors.

From the 1960s onwards, the challenge has been to squeeze more and more transistors – hence, more computing power – onto a single chip of silicon. The progress has been exponential. In 1965, Gordon Moore, then the Chairman of the world's largest chip-making company, Intel, predicted that the power of a chip would double every 18 months and its cost would halve. So far, he's been right. The chips of the 1960s and 1970s, called 8088s, contained 10,000 transistors. Those chips yielded to the 80286s, which managed to accommodate 100,000 transistors. The IBM 386 of the early 1990s packed in 500,000; the 486 raised the number to 1 million transistors; and the Pentium-Pro chip of 1997 squeezed in 5 million.

As Moore's Law worked its way through the last three decades, the computing power at our command has increased spectacularly. Whereas the computers of the early 1960s could do little more than arithmetical calculations, those available in the 1990s can design products, control aircraft navigational systems, and reproduce art. In May 1996, Texas Instruments announced that it was developing a new technology that will be able to pack in 125 million transistors on a single chip the size of a thumbnail! That development is expected to make possible applications ranging from the picture phone to the wrist computer, from speech recognition to ... well, things we cannot even imagine as yet.

Semiconductors are fast becoming the central nervous system of modern society. From computers to cars, radios, and home appliances, semiconductors are used in countless electronic devices. Even the ubiquitous wrist watch has been transformed by the semiconductor chip, which is used in quartz timepieces.

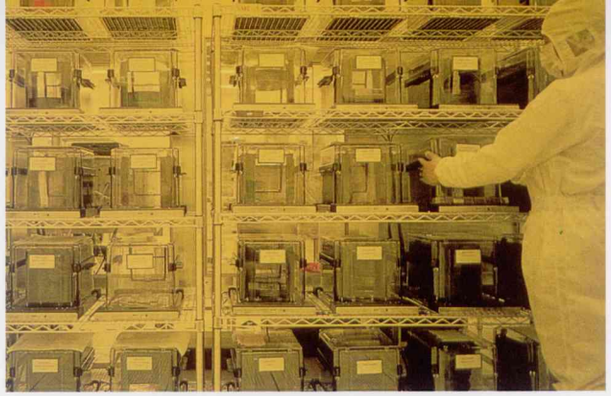


An integrated circuit chip with the ST logo. The chip business has extremely high stakes, but the rewards can be enormous. Wafer fab plants cost about S$2 billion to construct, but in a boom phase a year's turnover can equal that same amount.

But soon after, there was trouble, and from the least expected quarter. National Semiconductor – the biggest and, it was thought, strongest partner in the venture – found itself in difficulties. The semiconductor industry worldwide was experiencing one of its periodic downturns, and NS was restructuring and consolidating its manufacturing arms to meet the challenge. It had also acquired Fairchild two years earlier, and the acquisition proved financially burdensome. Given these circumstances, National struggled to meet its purchasing commitments from outside manufacturers such as CS. By the end of 1989, it pulled out of the venture. The portion of the initial 3,000 wafer-a-month capacity of the plant that had been earmarked for National was rendered idle.

CS suffered a blow. As a blue-chip name in the industry, National had lent a measure of prestige to the venture, its presence gave the staff much confidence, and it had been a customer that could be counted on. Because CS and National parted on good terms, CS managed to minimise the effects of the separation. Still, CS felt like a new soccer team which had lost its one and only big-league superstar.

But the game had to go on. The immediate need was to find replacement customers. Because of the worldwide industry downturn, Sierra too was not growing as expected. Its technology, moreover, was tailored to its own needs and lacked versatility. There were thus hardly any takers for Chartered Semiconductor's products. It was a dead-end situation.



Because semiconductors have to be made with such exacting microscopic tolerances, wafer manufacture has to take place in a clean room. Normal city air has about 350,000 dust particles per cubic foot, but a "Class One" clean room pod should have no more than one particle, about one-tenth the size of bacteria, in the same volume. To keep the air in the building clean requires high powered air-conditioning, and workers have to wear lint-free cleanroom garments from head to toe.

The only way out was for CS to reinvent itself. It moved away from being a captive producer to being an independent foundry capable of providing manufacturing services to multiple customers. This was unusual in the industry at that time. Captive wafer production plants were very much the norm. There was only one successful independent foundry in the world – the Taiwan Semiconductor Manufacturing Company (TSMC). Becoming a foundry would mean that CS would have to do its own R&D, and come up with technologies that were robust and flexible enough to supply a broad customer base.

In 1990, CS took on board its first Research and Development Director to spearhead the company's R&D thrust. This was Mr Chris Chi, a University of California, Los Angeles-trained Taiwanese-American who had worked with Rockwell and Xerox. The following year, the company hired Dr Klaus Weimer, a German-American. Ho Ching had flown off to Taiwan to meet with him when she heard that he was stepping down as President of TSMC, and he agreed to come on board as President of CS in May 1991.

ST also separated the production team at CS from the design team, which was transferred out to form TriTech Microelectronics International in 1991 (the company dropped 'International' from its name in 1997), as part of the consolidation of semiconductor design and marketing activities within the group. The reorganisation enabled ST to assess more clearly each team's distinct problems and needs. After the production/design split, Chartered Semiconductor was renamed Chartered Semiconductor Manufacturing (CSM). Sierra remained on board until 1993, when ST bought out its stake, though Sierra continued to be a customer of CSM.

For CSM, finding new customers in 1990 proved an uphill task. As Chi recalled, the company had to develop altogether new technology. It invested millions in new process equipment to yield products that conformed to mainstream industry standards. CSM also had to go through the time-consuming business of setting up from scratch marketing and sales channels in the US and elsewhere.

To add to CSM's woes in 1990-91, a semiconductor recession was gathering force. "We were sailing into a bad market", recalled Chi. Because of heavy investment costs, and with sales sputtering, losses mounted. By the end of 1991, the losses had accumulated to more than S$100 million.

The dynamics of the semiconductor industry are peculiar. If one took a five-year moving average of the industry's revenues, it would resemble a nice upward sloping curve. But at any given time, available supply can be out of sync with actual demand. When demand explodes, as it does from time to time – either because of a general pickup in economic growth, or the expansion of the PC market due to, say, falling prices, or the introduction of new computer software like Windows '95 – chip producers rush to add new capacity, which takes about two years to come on stream. But when that capacity is ready, there's too much of it, because all the producers in the industry had rushed to expand at the same time. The resulting overproduction is aggravated by the multiple-ordering of chips by buyers during the boom – which is inevitably followed by an

With the launch of ST Assembly Test Services (STATS) in 1995, ST now provides a complete array of semiconductor-related services. TriTech does design, CSM does wafer fabrication, and STATS does testing.

avalanche of cancellation orders as demand gets met. The result: producers with expanded facilities are stuck with rising inventories, idle plants and falling shipments.

A downturn in the semiconductor fabrication business is a time of crashing prices, falling margins and possible losses. It is also a time in which companies that lack the staying power either fall by the wayside or are swallowed up by others. Such was the global situation of the industry during 1991.

For ST, the semiconductor recession could hardly have come at a worse moment. Coping with it needed full-time attention, but there was also much fire-fighting to do in some of the group's other startups. For example, Aero-Engine Manufacturing of Singapore (AMS), which supplied aero-engine parts to Pratt & Whitney, was running losses. Another company, Origen, which tried to make computerised building security systems, was bleeding and had to be shut down. Even CEI, which had earlier picked up, was going through a rough spell. But CSM was the most serious case. As Ho Ching put it, it was as if a main artery had burst.

Some of ST's shareholders who had patiently, if reluctantly, put up with all of CSM's trials and tribulations thus far, were beginning to think that enough was enough. And though almost all of CSM's bankers continued to be supportive and encouraging, it was evident that the questions that were being asked within the group would sooner or later also be asked without.

In the circumstances of 1991, these were hard questions to answer convincingly. In fact, the questions that were being asked had no foolproof answers. There was, for example, no way to prove conclusively that the move to being a foundry was a good idea; no dead certain forecast of when the industry would turn around; no knowing for sure whether the capabilities of the staff were really up to the mark. Everything was a matter of instinct and judgment; there was precious little hard evidence to go on; there was only faith and trust to guide the way.

It so happened that a few members of ST's Board had that faith. They believed in what CSM was doing and they believed in its staff. The staff have no hesitation in pointing out who they were: ST's Executive Committee Chairman Philip Yeo, Singapore Technologies Ventures' Executive President Ho Ching, and CSM Chairman Lim Ming Seong.

But the evidence was against them. The red ink was there for everybody to see. Besides, CSM was a company that had no track record as yet. It had not proven itself in any way; it was, in effect, still an experiment. To have faith in a mere experiment in the face of pouring red ink seemed quixotic. As the months passed, the rift among ST's top decision-makers widened.

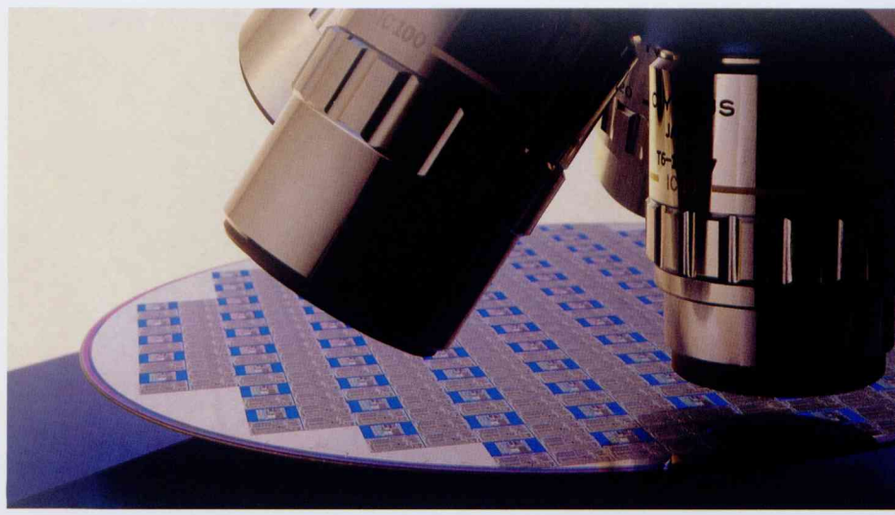
Meanwhile, over at the Fab, people were stressed out. Relations among managers were worsening; there was much bad-mouthing and finger-pointing. Morale was low. A few who couldn't cope with the uncertainty, resigned.

Pao Ning Yu and Chris Chi remembered those days vividly. "The elephants were fighting", said Pao, "and we were the grass underneath."

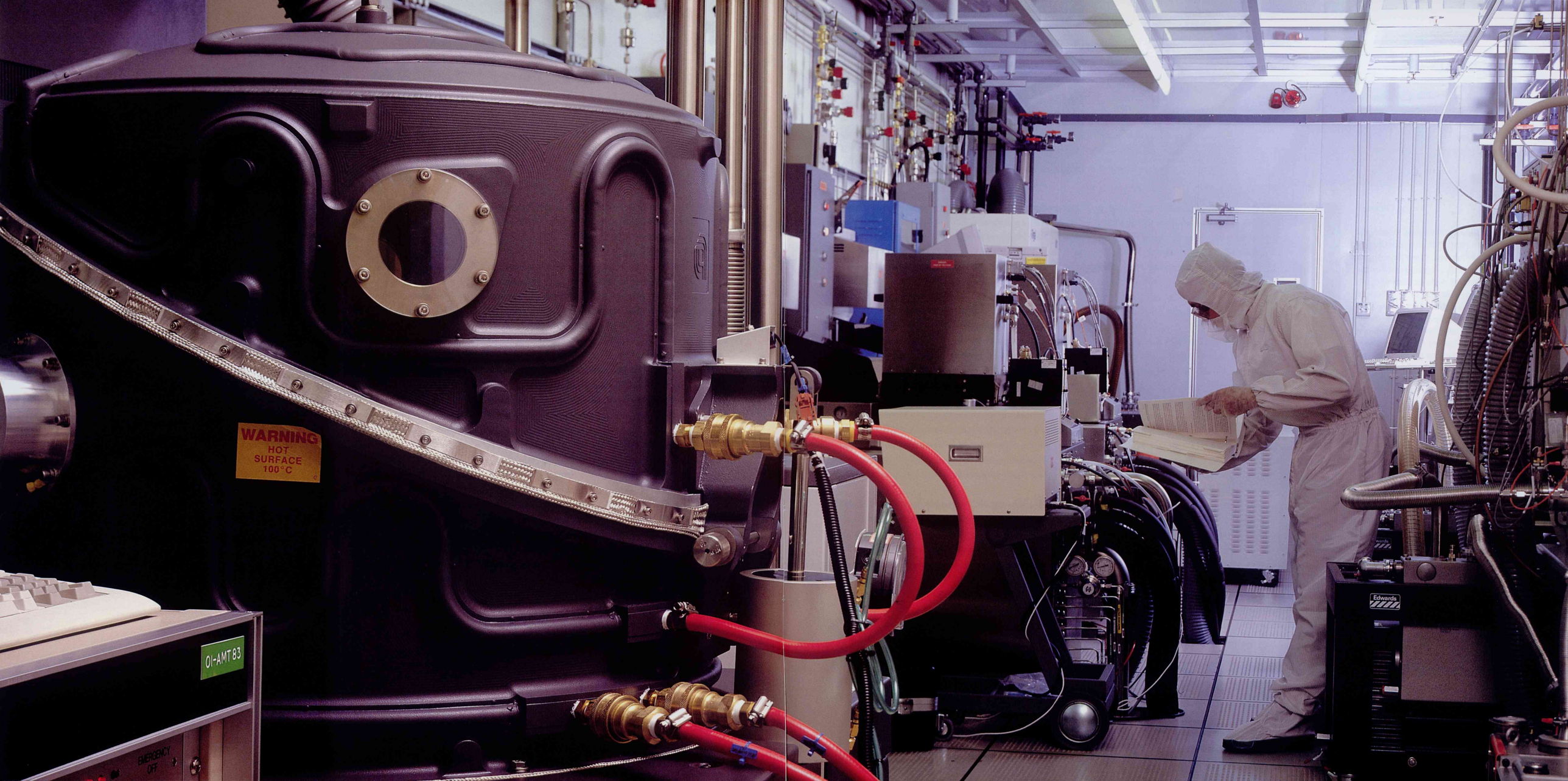
"We were trying to set up our systems. We were establishing sales and marketing channels, running after customers, trying to familiarise them with our technologies and our processes. While all this was happening, we were facing the prospect of closure. Everyday when we came to work, we wondered whether it would be our last day."

People looking after the financial affairs of CSM had an equally tough time. Ms Ong Peck Choo, who had joined CSM as head of Finance in 1991, recalled: "We were being closely monitored on a monthly basis and were under tremendous pressure to break even. Break even was like a sign of hope, a sign of light at the end of the dark tunnel. But sales kept missing targeted numbers, month after month. Everybody felt like time was running out on the company." "I was constantly called upon to provide and explain the numbers", said Ong. "Financial scenarios on various 'what-if' situations were drawn up every so often. These 'what-ifs' had to be kept confidential as they were very sensitive."

Despite all these pressures, the vast majority of CSM staff hung in there. They wanted to carry on, because they knew in their bones that given a chance, they could make it.



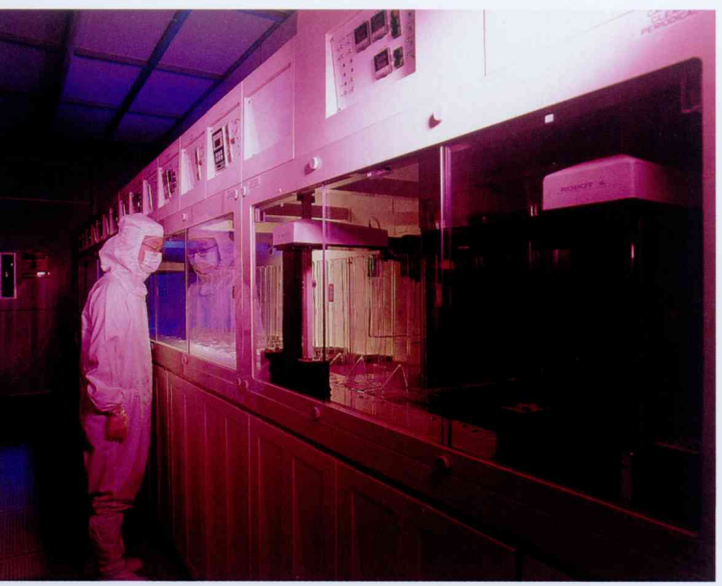
Inspecting a semiconductor wafer under a microscope. The power of the semiconductor is in its miniaturisation. The smaller its circuitry, the more transistors can be packed inside, which means more computing power per chip. In the beginning CSM was manufacturing 3.0 micron line widths, but by 1997, it was well into the submicron range, with line widths as small as 0.35 submicron. A micron is one millionth of a metre. A human hair is about 100 to 150 microns thick.


WARNING
HOT
SURFACE
100°C
01-AMT 83
EMERGENCY
OFF
Edwards

Previous Spread:
A CSM equipment technician working behind the maintenance 'aisle in the metal etcher chamber.

Dr Lau Chi Kwan

Dr Lau, Vice President, Research & Development, CSM, is responsible for the development of new process and device technologies, as well as the preparation and execution of CSM's technology roadmap. Dr Lau obtained his Phd in Electrical Engineering from the University of South California, and has worked in Hewlett-Packard and Texas Instruments. He has several publications in the field of semiconductor manufacturing, and has been awarded various patents. His motto is "do it right the first time".



Automatic wet benches are used in the cleaning and etching process.

"I remember the day when Ho Ching called all of us in and she asked us a simple question", recalled Pao. "She asked: 'Does CSM have a future?' All of us said 'yes'. We said: 'Look at the Taiwan foundry. If they can do it, why should we fail? We can compete. We just need support.'"

But getting support from the decision-makers was more complicated than merely being allowed to carry on. By early 1992, it had become clear to CSM that in order to be commercially viable, it had to expand its capacity from 9,000 wafers a month to at least 12,000. This, CSM's staff was convinced, was the minimum needed to support large-volume customers, and to drive down unit costs to a more competitive level. Also, CSM needed to enhance its technological capability from 0.8 submicron technology to 0.65 submicron technology. And what was the price tag for this proposed expansion and enhancement? – a S$70 million package from a syndicate of banks. It was like waving a red flag before a bull.

Of course, by the standards of the industry today, $70 million was a modest sum. But for those among ST's top decision-makers who were getting impatient with CSM, it was a galling demand. Here, after all, was a company with no track record, spewing red ink, faced with a recession, a company that probably ought to have been closed down a long time ago, and its people were asking not only that they be permitted to remain afloat but that they be provided with more resources to expand?

After an agonising debate, ST's Board voted in favour of the $70 million investment by an overwhelming majority.

TriTech Microelectronics boasts an aggressive in-house design and development programme, and specialises in custom and semi-custom designed Integrated Circuits (ICs) for a wide range of applications. The company has made advances in digital and analog signal processing IC design techniques.

However, this decision was not to be conclusive, and was held in abeyance soon after it was made.

CSM's supporters refused to give up. They continued to lobby and plead their case. On paper, there were three options: to close down CSM; to continue operations without making any further investments; and to invest $70 million in expanding capacity. The management of CSM understood that in reality, options one and two were essentially the same: if there was no additional investment, CSM didn't stand a chance, and it might as well be closed down. It was either option three or nothing.

Preparing for the worst, CSM's management worked on a back-up plan – a fourth option. A core group of true believers within ST considered buying-out CSM themselves and raising the $70 million needed on their own, if they were not given the green light to expand. Lim Ming Seong worked with bankers to explore this possibility.

Philip Yeo, who had supported CSM all along as ST's Executive Committee Chairman, was willing to execute option four on his own. He was certain it would work and was confident of mobilising the resources that were needed.

"I asked the ST Board: 'What do you want to do with this company?'", Yeo recalled. "If you don't want it, sell it to me. I will take 60 percent and you can take 40 percent, or you take 60 percent and I will take 40 percent. I will resign from government service tomorrow morning, and I will run it."

ST's Board qualified its earlier approval by setting two conditions on the proposed $70 million investment. First, that there should be a timeframe within which CSM would break even. And second, that CSM would find a major semiconductor company prepared to invest in CSM, or at least indicate in writing a willingness to make such an investment. The latter, the Board felt, would give some credibility to the possibility of a turnaround.

There were indeed some large semiconductor firms that were willing to come in, both as investors and technology partners. But the price they demanded was extraordinarily high. Some of them wanted as much as a quarter of the company just to lend their names. Philip Yeo, however, thought there was a chance that there was one company that might just be open to doing a reasonable deal: Toshiba of Japan. So he, together with Ho Ching and some staff, took the overnight flight to Tokyo. There, they presented their case to Dr Tsuyoshi Kawanishi, Senior Executive Vice President of Toshiba, and his team.

The Japanese were receptive, but they were not accustomed to taking decisions of this sort in a hurry. They needed to arrive at a consensus among themselves first. Besides, Japan was at that time in a deep recession. Its corporations were busy restructuring their operations and were holding back from making additional investments. But the Singaporeans persisted. Finally, a formula was found that the Japanese could accept, and Toshiba gave CSM a Memorandum of Understanding (MOU) indicating Toshiba's intent to invest in CSM. That MOU was presented to the ST Board a couple of days later.

ST Computer: The Comeback Kid

The story may not be as dramatic as CSM, but ST Computer is another instance of an ST company that faced tough times and overcame challenges by reinventing itself.

Originally called Singapore Computer Systems (SCS), ST Computer Systems & Services Ltd was launched in 1980 by spinning off the electronic data processing department of CIS. It focused initially on computerisation projects for Mindef and the ST group.

By the end of 1985, however, when Mr Tay Siew Choon came on board as CEO, most of the company's in-house and Mindef-related computerisation projects were near completion, and the company was not doing well. In 1986, SCS ended up with a loss of about $2 million.

The situation was further complicated by the fact that SCS was competing head on with one of its subsidiaries, Computer Engineering Systems (CES). Focusing originally on the maintenance of computer mainframes, CES subsequently moved into software development, like SCS. When personal computers began to be popular in 1985, both companies entered the business, with SCS focusing on retailing and CES on linking PCs with mainframes.

Tay saw that SCS and CES had to change their missions. Both companies needed to expand into other markets, within Singapore and regionally. They also had to respond better to the rapid technological changes in the computer industry. "We needed to strike a balance between keeping abreast of cutting-edge technology and yet knowing some technologies well enough to be able to offer practical solutions to our customers", said Tay. "And I had to make sure that the two companies did not compete with each other head on."

To execute the new game plan, SCS and CES began to build relations with more computer manufacturers, intensified their training programmes and strengthened their marketing. They also began to work on developing a common team spirit. In addition, they looked for opportunities in the region. By 1986, they established a presence in Malaysia, and in the following year, set up an office in Beijing to support operations in the PRC.

Tay and his team took an unorthodox approach in transforming the companies. "We did not cut costs and reduce staff. On the contrary, we increased expenditure on marketing and technology, and expanded our staff." The payoff was rapid. By the end of 1987, both companies were profitable again, and in 1988 profits rose more than 100 percent.

But the challenges ahead still loomed large. The computer industry was going through tumultuous changes. Providing software solutions now involved not only dealing with text and data, but also with graphics and video. And building computer networks became more complex.

In 1990, SCS and CES were merged into ST Computer. "The aim was to eliminate the duplication of technical and management skills and to focus on the marketplace rather than on internal competition", Tay said. In 1991, ST Computer was listed on the Singapore Stock Exchange.

A research and development (R&D) division was established within ST Computer, funded out of profits. When the company had to choose between doing incremental R&D to improve the efficiency of existing products or exploring altogether new areas, it chose the latter. "We decided to go into areas where we thought developments were still in the early stages", said Tay. "In this business, if people are talking about the same thing and you see it in books and magazines, it's already too late."

One new area was "object technology". A way of developing software in a modular form so as to make it flexible and reconfigurable, object technology can be used to create software components for different applications, making customisation of software easier.

The second area was automated query systems. Similar to search engines, such systems enable users with little IT knowledge to find complex information within large databases: for example, a business manager may want to find out the number of engineering projects undertaken over a year, their contract values, profit margins, the names of project engineers, their pay and experience, and so on.

The R&D efforts proved to be tough going. "What's tricky about doing R&D", said Tay, "is that you're operating on a constantly shifting base. You may succeed in making a breakthrough, but it may become obsolete quickly, and you have to move on."

Nevertheless, ST Computer met with some success. It has filed eight patent applications, and five have been approved: two in object technology, one in neural engines, and two in query engines.

It licensed some of its object technology to a US company, Versant Object Technology; and its research in the field provided the base for the development of a hospital management system for a hospital in Singapore. In the area of query systems, it developed a product called Infoscout, which is now used by some ministries in Singapore, as well as by corporations in both Singapore and the US. In July 1996, ST Computer, together with the Vertex Venture Group, established a new start-up in San Francisco called D2K (which stands for "data to knowledge"), to expand its query technology into a complete datawarehouse/datamart product.

Over the last decade, therefore, ST Computer has come a long way. Between 1986 and 1996, its revenues increased from barely S$50 million to S$330 million, and its post-tax profits grew by an average of 20 percent annually. "When I came in 1986, I set three broad objectives for the company", said Mr Tay. "One, turn the company around; two, make it a profitable regional software house; and three, produce truly world-class products through R&D."

"We have achieved objectives one and two. We are working on the third. We're getting there."

In the meantime, an emergency meeting was also arranged with some of the top brass of the Singapore government to consider CSM's future. Philip Yeo recalled that at the conclusion of the tense meeting, the team from ST was asked to wait outside the meeting room. They were called in after five minutes. The verdict? Green light – go for option three. CSM was saved, in the nick of time, from almost certain death.

In November 1994, when Ho Ching recounted at a staff dinner CSM's rescue from the precipice, she had words of special appreciation for Toshiba and Dr Kawanishi. "He knew our problems," she said, "and reached out beyond what would be normal for a company of his size and gave us that precious letter. This was very, very unusual for a Japanese company. It bought us time and the approval to invest to bring the capacity up to 12,000 wafers per month. CSM owes its lease of life and success today to that extraordinary gesture of support by Toshiba."

And yes, Toshiba did invest in CSM. In October 1994, it took a $5.9 million stake in CSM's Fab 2. Its participation was welcomed especially warmly by CSM.

Looking back at the events of 1990-92, the CSM staff are deeply grateful for the faith placed in them when the chips were down, and for their top management's capacity to look beyond current problems while coping with those problems at the same time. It would have been so much easier to just let CSM sink. Keeping it afloat, bringing it to shore and reviving it, was, as Pao Ning Yu said, "a gutsy entrepreneurial decision".

It was also a decision that had a wider significance. "If CSM had been closed down, it is doubtful that Singapore would have been able to attract any semiconductor companies", said Pao. "So in a sense, the decision to rescue it was a strategic decision for the Singapore economy."

As CSM entered the second half of 1992, its turnaround was within striking distance. There was still a semiconductor recession, but CSM's earlier marketing efforts had begun to pay off by now. On the R&D side, Chi and his team had come up with a 'technology road-map', which indicated clearly what technologies CSM had developed and how these would evolve. This enhanced customers' confidence in CSM's capabilities. By the end of 1992, CSM had achieved its first break even month. With the recession in the US tailing off, orders began to pick up.

In April 1993, Dr Klaus Weimer relinquished his office as President. He had provided yeoman's service seeing CSM through the worst of its problems, and leading the initial turnaround. He was replaced by Mr Tan Bock Seng, who had already spent close to 24 years in the semiconductor business, 17 of them at Texas Instruments.

CSM still had lingering problems when Tan came on board. The traumas of the past had taken their toll on staff confidence and "people were still afraid and were not aware of their true capabilities", Tan said. His first challenge was to make them believe in themselves. As someone who had come from outside, he saw at once that the scope for doing things better and faster – from responding to customer needs to developing new technologies – was immense.

On the R&D side, CSM had managed to develop smaller featured semiconductor technology, going from 3 microns in 1988 to 0.8 submicron in 1992, thanks largely to the efforts of Chi and his team through the hard times. A micron is one-thousandth of a millimetre, or about a hundred and fifty times thinner than a human hair. The smaller the circuitry, the more transistors can be packed into a chip. That means more computing power per chip. In 1993, however, the industry standard was 0.6 submicron. CSM was therefore trailing technologically. The R&D team worked on fixing that, which they did. By mid-1996, CSM's technology had improved to 0.35 submicron – on par with the best in the industry.

Another problem in 1993 was production capacity. With an upswing under way, the need for expansion had become urgent. Tan therefore immediately set about expanding the capacity of Fab 1. Within one year, it was up from 8,000 wafers per month to 18,000. By 1995, this figure had been pushed further upwards to 27,000.

In 1993, ST also took a long-delayed decision to build a new facility, the S$1.3 billion Fab 2 in Woodlands. Though the concept of a Fab 2 was first explored way back in 1990, and was firmed up during Klaus Weimer's tenure as President, the decision to proceed with it in 1993 was still difficult: "To even broach the subject of Fab 2 when Fab 1 had only recently been profitable for six months out of its four years of operation was hard", Tan said. "But we had customers willing to invest in us and the bankers were willing to take us public."

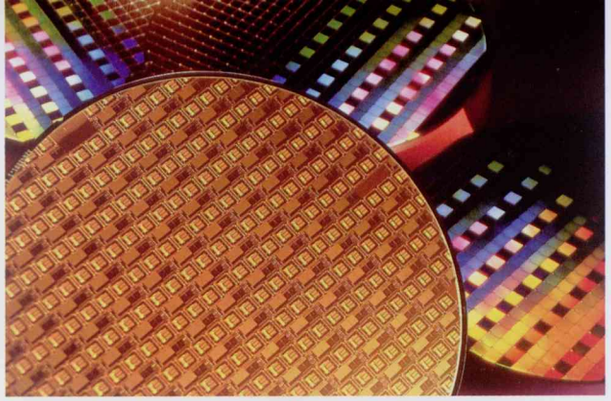
Fab 2, located at Woodlands Industrial Park, started shipping out eight-inch wafers barely 16 months after groundbreaking. CSM's Fab 1 had been profitable for only six months out of its first four years of existence, when CSM's management decided to go ahead and build a new fab to expand capacity. Their guts and foresight was to pay off in the semiconductor industry boom phase of 1995.

A cluster tool used for oxide or metal deposition in the thin film section of the fabrication process.

And so, by the end of 1993, Tan got the green light to go ahead. The financing, which took barely six months to put together, came largely from CSM's own resources, with some equity injections from Rockwell, Actel, Brooktree Corporation, LSI Logic, ADI and Alliance SMC. The Fab would start with a production capacity of 24,000 wafers per month, which would later be increased to 40,000 wafers per month. By February 1994, construction had begun on Fab 2, and by the end of the year, equipment installation was underway.

"We decided we would begin production even though we hadn't finished building the factory", Tan pointed out. Nobody in the industry had done this before. The normal approach is to wait till the entire factory is complete, but CSM built the inside of the factory first and got started with production while the outside was still being done. "When our customers first heard about it, they were leery as hell. But when they actually came and saw the place, they said, 'hey, you've done the right thing!'"

Having ended 1993 with sales of S$149 million – S$86 million more than in the previous year – CSM's good fortunes carried over into 1994, a year in which its revenues rose 57 percent, to S$234 million. Nineteen ninety-five turned out to be a banner year. By then, the semiconductor industry was well into its boom phase and a major chip shortage had emerged. With the benefit of the additional capacity from Fab 2, CSM was able to raise its revenues by more than 70 percent.



CSM has one of the most advanced integrated circuit (IC) processing facilities in Southeast Asia, capable of processing materials at submicron levels. The company has received various patents for innovations in manufacturing processes, as well as research and development grants to develop IC chips of ever shrinking geometry.

In August 1995, the ST group launched a new company, ST Assembly Test Services (STATS). With that, the group was able to position itself as a provider of a complete array of semiconductor-related services. TriTech could do design, CSM could do wafer fabrication and STATS could do assembly and testing.

"We have now arrived at a position where we have a good chance of developing into a major player in the semiconductor industry", said Ho Ching. "Today, in the world foundry market, we are number two. Number one is TSMC of Taiwan. But hopefully, like Avis, the number two US Car Rental Agency, we will try harder, and in time to come, become number one."

Nineteen ninety-six proved to be a mixed year for the industry. While growth was positive in the first four months, by mid-year, it was evident that a new recession had hit. Earlier industry forecasts were dramatically revised. At the height of the wafer fab frenzy in 1995, the projections were that the industry would grow by 20 percent in 1996. By July 1996, this estimate was scaled back to between minus 9 and minus 7.6 percent – a stark illustration of how tricky it can be to read the semiconductor cycle.

The tough times thus returned. But this time, CSM faced up to the difficulties with a stoical equanimity. It had been there before. "We decided to build Fab 2 and Fab 3 knowing that the market will turn soft from time to time and that we'll have to bite the bullet", said Tan. The company had also learnt a thing or two about how to cope with adversity. As Pao put it, "success in the semiconductor business is not so much determined by how you do during the good times. It's what you do in the bad times that really matters."

CSM therefore viewed the recession of 1996 as an opportunity. It was an opportunity to discover what the market will want when the upswing got under way. And it was an opportunity to develop smaller submicron capabilities – CSM, for example, did research, jointly with local educational institutions, on 0.25 submicron technology. Tan pointed out that the recession was also an opportunity for CSM to diversify its products and broaden its customer base in such markets as PCs, telecommunications, consumer goods and toys. To this end, it established offices in Europe and Japan. In addition, it looked to build plants overseas so that it could have a presence close to major markets and to large pools of technical talent.

In due course, good times will return to the semiconductor industry. And after that, there will be another downturn. Such is the nature of the industry. But way into the future, after many cycles have come and gone, the events of 1990-92 will still loom large. Those who were there will remember it as the period which defined the spirit of CSM. It was a time when people gave meaning to the words Integrity, Value Creation, Courage, Commitment and Compassion – words which today define the group's core philosophy.

ST has had many good moments in its history; but next to its founding in 1967, the fall and rise of CSM was, undoubtedly, its finest hour.

柳暗花明又一村
山重水复疑无路

The above passage from a Song poem was cited by Ho Ching as expressive of a spirit that finds opportunity in the midst of crisis, new possibilities in every seeming failure.

The passage comes from a poem by Lu You, "Visiting the Village West of the Mountain", and translates literally as:

Mountain after mountain, river after river,
it seems there's no way through.
Yet lo and behold!
Another habitat unfolds,
amidst the brilliant flowers and shady willows.

QWERTY

The next time you sit before a computer, take a look at the keyboard. The top row of the letter keys reads, left to right: Q, W, E, R, T, Y.

Why? As anyone who types knows, the arrangement of the keys is by no means intuitively rational. Is there, therefore, a technical reason for this arrangement? Well, yes, there *is*, but it is a reason that ceased to be reasonable about a hundred years ago.

The present arrangement was determined in the 1890s for an altogether trivial reason: it happened to be the layout that minimised the jamming of keys on the first primitive typewriters. Though electrical typewriters and computer keyboards hardly ever jam anymore, this particular layout – QWERTY – will remain unchanged. Once typewriters with the 'universal standard' flooded the market, it was already too late for any other layout, no matter how superior, to replace the first. It is simply too expensive, and a century too late, to change now.

Keyboard design is only one example of what economists call 'path dependency'. The term refers to the process by which seemingly random events can conspire in the market place to determine technological choices, or paths, which are then difficult or impossible to change.

The best contemporary example of this is how Microsoft established the industry standard for personal computers. This was not a pre-ordained event. It was Apple, not IBM or Microsoft, which made the first popular personal computers, and as early as 1983, it produced the Macintosh.

It was only in 1995, more than ten years later, that Microsoft, with its Windows programme, managed to match the look and feel of the Mac. But despite this advantage, Mac's market share has never topped more than 10 percent, while Microsoft continues to move from strength to strength. How did that happen?

Apple made a serious marketing error at the very outset – it did not license the Mac software to competitors. This allowed the market to be flooded with computers using Microsoft's MS-DOS operating system. Economies of scale resulted in their becoming cheaper than Macs, and software developers concentrated on making applications for MS-DOS machines. Microsoft had locked itself into a virtuous cycle, a dependable path; Apple hadn't.

A similar thing happened in the competition between Sony and Matsushita in developing video cassette recorders. By most accounts, Sony's Betamax was better than Matsushita's VHS, but Sony lost anyway. Its tapes were initially too short, and it didn't license Betamax to other producers. VHS, on the other hand, played two-hour tapes, and its manufacturer licensed the standard to all. Almost overnight, Matsushita's initial advantages ballooned into an irreversible lead, and Betamax, despite its superior qualities, became history.

But when compared to something like the petrol-powered car engine, VHS and MS-DOS are minor examples of path dependency. The modern car need never have existed in the form we know. Electric and steam cars, far from being cutting-edge technologies, were actually coterminous with petrol-powered cars. History might

have turned out differently if not for a series of accidents and blunders.

Indeed, at the turn of the century, the petrol-powered car was by no means superior to the alternatives. The Stanley Steamer, for example, set a world record of 122 miles an hour in 1909. Imagine that – a car powered by water! Unfortunately, two things got in its way. First, the manufacturer priced it as a luxury car, and thus failed to achieve the necessary economies of scale. Second, an outbreak of hoof-and-mouth disease in the US closed public horse troughs in 1914, and denied steam cars convenient stops to replenish their boilers. Of course, if there had been enough steam cars around in the first place, entrepreneurs might well have set up watering stations just for cars, just as we have petrol stations today all over town. But there weren't enough steam cars, and there weren't any watering stations. Dying of thirst, the Stanley Steamer went the way of the dodo bird.

"Apparently," said Peter Passell, a writer on economics and technology who has studied the issue, "all the gasoline engine needed was a brief period in which its technological and price edge led to rapidly expanding sales. This cut production costs, which expanded sales even more." Today, dependence on gasoline engines is a fact of life, and it would take an investment of hundreds of billions to reverse it.

Such remarkable facts have led economic historians to a few conclusions about the intersection of technology and the market place: Firstly, they have concluded that where basic technological choices are concerned, what seemed at first to be just one among many paths, can become the royal road down which all will follow. Once that path is established, even a detour may become so expensive that it might well be impossible to get off the beaten track.

Secondly, path dependency means that the best doesn't always win – or at any rate, the definition of 'best' needs to be rethought. Unless technological superiority goes hand in hand with a wise marketing strategy, the best can lose to the second-best. "Full many a flower", said William Wordsworth, "is born to blush unseen and waste its sweetness on the desert air." The same it seems might well be said about many technological inventions.

And thirdly – and perhaps most pertinently, where Singapore is concerned – the principle of path dependency means that technology-based companies have to be very careful in choosing the niches they pursue. Singapore, with its limited resources, can hardly afford to sink billions into developing, say, high-definition television, as the Japanese did in the 1980s, only to see it become a museum piece before the first HDTV is sold.

As in biological evolution, any number of promising avenues in technology can turn into dead ends, and only a few are throughways. Guessing in advance what those paths are likely to be requires that most imponderable of all business qualities – Foresight.

Previous Spread
Engineers at TriTech discussing integrated circuit design.

Yeo Chee Tian

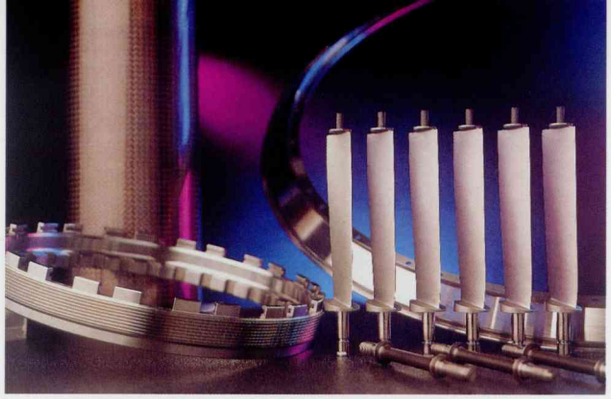
Yeo is General Manager of Advanced Materials Technologies (AMT) and concurrently GM, Commercial Business Group, CIS. Started in 1990, AMT designs and fabricates precision metal injection moulding, and is the only such company in Singapore. Yeo joined CIS in 1980, his first job upon leaving National Service. One of the advantages of working in ST, he feels, is that there are a lot of opportunities for career advancement and flexibility. During his days at CIS he couldn't have imagined that he would end up in AMT, which he joined in 1993. Among all the various things Yeo has done in ST – including product engineering, process engineering and applied mechanics – he is most excited about his current post at AMT.

Advancing on the Cutting Edge: STV and After

While CSM was riding its rollercoaster, activity elsewhere in the ST family was frenetic. The other companies had been busy not only consolidating what they had already achieved, but also venturing into new fields.

A family portrait at the start of 1990 revealed four basic functional areas: the industrial side, grouped under STIC; ordnance activities under CIS; aerospace under ST Aero; and marine under ST Shipbuilding. By now, the process begun by Philip Yeo in 1979 of identifying capabilities within the group, and spinning them off into stand alone companies, was already well advanced. Most of the companies founded in the late 1980s – eleven, including CSM – were technology-focused. Not all of them broke even quickly. They needed time to incubate, to learn and to develop.

In 1990, the management of STH decided to regroup all the fledglings under the umbrella of a venture company called Singapore Technologies Ventures (STV), which was formally set up on the 24th of September 1990. STV would take over from STIC the role of parent to the start-ups in the area of emerging technologies, overseeing their growth and development, and pointing them in the right direction. Another reason for setting up STV was that STIC would be freed from the financial responsibilities of being a parent: the departure of the fledglings meant that the established companies within STIC could seek public listing on the stock exchange. It was under these circumstances that CSM was transferred from STIC to the STV stable.



Aero-engine parts manufactured by AMS Precision Engineering, a subsidiary of Singapore Technologies Precision Engineering.

STV, though, was not an instant success. The fledgling companies had been transferred from STIC to the STV stable at their original book-value, though several by then had a negative net worth. In 1992, after a strategic review of all the companies in its stable, STV undertook a rationalisation of its assets. Deciding to swallow the pill, STV wrote-off non-realisable assets, including losses the startups had accumulated before being transferred out of STIC. The losses amounted to nearly $270 million, of which $240 million was written off.

"That was when fingers started pointing in my direction", recalled Yeo. "I had always maintained that there was nothing wrong with STV. The rationale was right. It was set up to nurture the new ventures through the early stages of product and market development. The losses of these startups only looked more stark when they were transferred out of STIC. CSM, which was the largest loss-making subsidiary of STV, had pulled down the results as a whole."

In time, Yeo was to be vindicated. By 1994, STV, with a turnover of $552 million and profits of $69 million, was one of the most profitable arms of the ST group.

The CSM turnaround was, of course, a large part of the story of how this happened. But it was not the only part. For example, Vertex Investment, the group's venture capital arm, which focused on technology investments, including in emerging markets in Asia, was a star performer, as was AMS Precision Engineering. TriTech Microelectronics (a sister company of CSM), which designed specialised semiconductors, was also a money spinner.

But the bottom line apart, there was also another dimension to the success of STV. Its establishment formally institutionalised within the ST group the process of striking out in new directions, and of investing in cutting edge technologies. As a full-time parent, STV could look to adopt other promising children to nurture and groom into strong, capable and dynamic adults, so to speak – just as it had done with CSM.

And so, the creation of STV triggered a wave of diversification by the ST group during the 1990s, and not only in technology-based areas. The approach to diversification was flexible. It was sometimes done through the establishment of fully-owned subsidiaries, and at other times, through partnership with others, or through acquisitions. Diversification involved extending already established core competencies or moving into new but related areas. The ventures established in this period include:

- Agilis Communication Technologies. This was set up in 1991 to manufacture high-reliability microwave components and sub-systems for the telecommunications and defence electronics industries. It developed into a major supplier of low-cost VSAT (Very Small Aperture Terminal) satellite receivers in Asia.

- Chartered Systems and Networks, which was started first as a joint-venture in 1991, specialised in providing computer networking and related services. It has executed major contracts in Singapore, China and India.

In 1995, ST Auto and Singapore Bus Service merged their taxi subsidiaries to form CityCab. CityCab's taxis are equipped with a satellite-based dispatch system made by CEI Technologies, an ST subsidiary.

- ST Assembly Test Services, which was set up in 1995 to provide semiconductor assembly and testing services. It broke even within 12 months.

- Singapore Technologies Telemedia, formally established in 1995, became the holding company for the ST group's diversification into the telemedia business. Its companies include ST Mobile Data, which provides mobile data applications and satellite-based vehicle location and tracking services; Singapore Cablevision, a cable TV operator; Cyberway (a joint-venture with Singapore Press Holdings) an internet service provider; and ST Messaging, which provides paging and messaging services.

- Dornier Asia Medical Systems, first set up jointly with Dornier Medizintechnik GmbH of Germany in 1994, to develop, manufacture and market high-technology medical equipment. Among its activities was the establishment of a urology centre in Guangzhou, China, the manufacture of X-Ray and other sensor sub-systems and components, and the development of a low-cost lithotripter.

The Compact S lithotripter, from Dornier Asia Medical Systems, an ST subsidiary, uses shockwaves to disintegrate kidney stones. It is a space-saving, cost-effective device capable of being used in mobile units. A special feature of the Compact S is that it is also suitable for orthopaedic applications such as treating chronic calcinosis of the shoulder, tennis elbow and painful heel spurs.

Of the diversifications during the 1990s, two were especially large in scope and potential. One of these was property. Over the years, various ST companies had been acquiring properties. By 1995, the group owned or managed some S$4 billion worth of property assets: S$800 million in Singapore and S$3.2 billion overseas. But in 1996, there was a major development that added a new dimension to the group's property business. The group's parent company, Temasek Holdings, decided to rationalise its own property assets. It did this initially by injecting these assets into another of its subsidiaries, Pidemco. In 1995, Temasek began to explore how to make Pidemco a bigger international operator. To do this, Temasek needed a vehicle.

"I think Temasek looked very seriously at DBS Land and Straits Steamship Land", Ho Ching explained, referring to the property subsidiaries of two other GLCs, DBS Bank and Keppel Corporation, respectively. "But the difficulty was that both companies were listed. This apparently would have complicated the restructuring of Pidemco. This is where we had some advantage. We were the only 100 percent Temasek-owned GLC at the group level. Temasek was also looking at a group that could help leverage Pidemco's capabilities to go international. And that fitted us, because we were already looking at property as another way of going regional."

It was for these reasons that in April 1996 Temasek Holdings and ST agreed that Pidemco would be injected into the ST group. At the time, Pidemco held property assets worth about S$4.3 billion.

SAFE is today a successful retailer of a wide range of home products, but its humble beginnings were as a supermarket for SAF personnel.

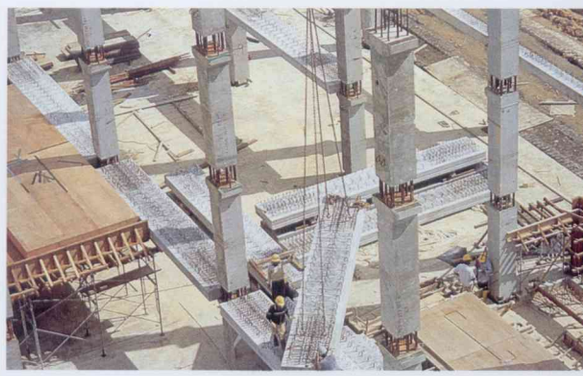
Mr Liew Mun Leong was appointed President of Pidemco Land. Although headhunted from another local specialist engineering contractor, he was no stranger to the ST group. As a civil engineer with Mindef, he had been a founding director of the defence industries' construction arm, which was set up in the early 1980s to build installations such as airbases and firing ranges.

Pidemco's mission, Liew said, was to become a leading property developer and investor in Singapore, expand its presence in the Asia-Pacific region, and export its property management services. This formidable new addition to ST's stable would also help stabilise the performance of the group, he said. "High-tech industries are prone to ups and downs. Property will help offset the risk of ST's high-tech ventures." Pidemco and its high-tech affiliates could also co-operate in developing intelligent buildings, and plug into each other's overseas networks, he added.

The second area of diversification that was particularly significant in the 1990s was that relating to infrastructure and lifestyle in the region. Though various companies in the group had by now established operations overseas, it was not until the group embarked on major infrastructural projects in, first, Indonesia, and then, China and India, that ST's regionalisation drive moved into top gear. The third stage of ST's diversification – regionalisation, globalisation – had begun.

Actually, unbeknownst to the rest of Singapore, ST had embarked on establishing the nation's 'external wings' well before the phrase became a staple of newspaper headlines.

Junction 8, a shopping-cum-office complex located near the Bishan MRT, is a showcase of Singapore Technologies Construction's innovative technological prowess. Using their award-winning buildable design approach, more than 70 percent of the building comprised precast elements. The top-down building technique enabled simultaneous above-ground and basement construction. Junction 8 was completed in a record time of 16 months. If traditional methods of construction had been used, the building would have taken two full years to complete.



A Computer in Every Gene

Like other living beings, we have within us molecules called DNA, or deoxyribonucleic acid, which contain the blueprint for what we are – our height, the colour of our eyes, everything that makes us biologically ourselves. DNA, in other words, may be defined as a code of instructions which, when decoded, yields an answer, determines a result.

But that is precisely what computers do. Are DNA molecules, therefore, computers? If so, can we harness DNA molecules to perform the tasks that conventional computers perform?

Those were the questions that a scientist at the University of Southern California, Leonard Adelman, found himself asking in 1993. He decided to conduct an experiment by setting up a computational problem and trying to solve it using DNA molecules.

The problem he chose is a well-known one in mathematics called the 'travelling salesman problem'. Suppose a salesman has to visit five cities. What's the shortest route he can take so he covers all five without visiting any city twice? So long as the number of cities is five or less, one might be able to work out the answer on a paper napkin.

But when there are 20 cities, the number of possible combinations is too high and a computer is needed to work out the answer. With 100 cities, the number of permutations soars to 93 followed by 156 zeroes. Not even the fastest of today's supercomputers can handle that.

To explore whether DNA molecules can compute, Dr Adelman tried his experiment with seven cities and 14 possible interconnecting flights. The challenge was to figure out the shortest way to get from city one to seven while covering every city in between. So he got 21 test-tubes containing DNA molecules and assigned one for each city and interconnecting flight. Each of the 21 test-tubes had its own DNA-name.

Next, Adelman poured the lot into a tiny bit of aqueous solution, mixed everything together and let the molecules do their work. Out of that alphabet soup, there emerged one long strand of DNA molecules, which when decoded, contained the answer. The world's first molecular computer was born!

Others then started to make refinements to Adelman's discovery. A Princeton computer scientist, Michael Lipton, worked out a coding system to convert the chemical units that make up DNA molecules into strings of ones and zeroes – the foundation of the binary logic at the core of a conventional computer's brain. Thus, DNA-based computers were rendered programmable.

A DNA computing system would bear no resemblance to a conventional computer, raising the question: what is a computer? "To some, a computer is a physical device in the real world", Adelman observed. But the possibility of DNA computers made him think instead, that "being a computer is something that we externally impose on an object".

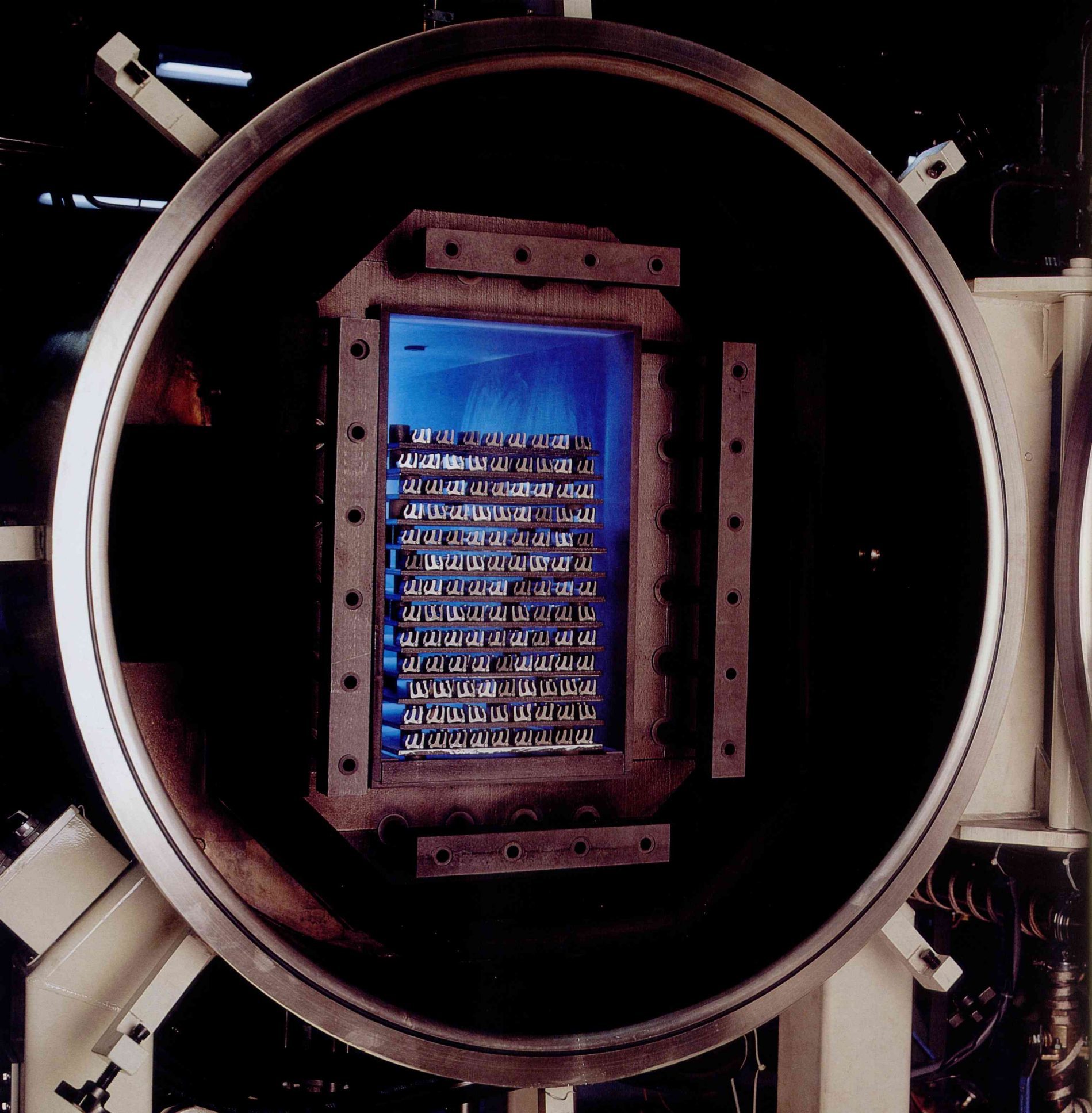
Although DNA computers are a long way from everyday reality, scientists are already beginning to appreciate their exciting potential. Clearly, if they come to fruition, such devices

would be far superior to the best of today's supercomputers.

DNA computers would be a billion times more energy-efficient than conventional ones and would use a trillionth of the space to store the same amount of information. (In Dr Adelman's experiment, the 'computer' measured approximately one-fiftieth of a teaspoon.) Such computers would also be thousands of times faster than the best of today's. This is because DNA molecules work on the basis of what's called "massively parallel computing". With trillions of DNA molecules undergoing chemical reactions simultaneously, it will be possible to do more operations at once than all of today's computers put together.

"There are more things in heaven and earth," said Shakespeare's Hamlet, "than are dreamt of in your philosophy". If only the Prince of Denmark had known the full extent of the truth he barely glimpsed. Things in heaven and earth? Forget those. There are more possibilities hidden in the DNA molecules swimming around in our ear lobes, say, than even the most wide-awake fantasist, let alone philospher, could have dreamt of barely five years ago.

A computer illustration of a DNA molecule.



CHAPTER FOUR

VENTURING BEYOND

Just as the limited defence pie had forced Singapore Technologies to develop civilian businesses, so too Singapore's limited domestic market prompted the company to look beyond the island for opportunities to grow. Years before regionalisation became a staple of newspaper headlines, ST began to regionalise and globalise its operations. These efforts would change the company's self-conception. It would no longer be just a Singaporean company, but an MNC in the making.

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VENTURING BEYOND

No man is an island, entire of itself; every man is a piece of the continent, a part of the main ...

John Donne

Twenty kilometres south of Singapore lies the Indonesian island of Batam. In the 1970s, most of it was dense jungle ringed by small fishing villages. The total population was less than 70,000. At the solitary tourist facility, the rustic Batam Island Country Club, visitors could sit on the verandah and on a clear day, catch a glimpse of Singapore's southern skyline. Batam's tiny town centre, ten miles from the ferry terminal down a dirt road, had the feel of a village square. Hawkers, street-vendors and fishmongers offered their wares to sparse crowds. A few stores, housed in makeshift single-storey shacks, sold basic provisions.

It would have taken a leap of the imagination in 1970 to suppose that by the mid-1990s this sleepy tropical island would have tripled its population, and become home to subsidiaries of close to 100 multinational corporations. Today, Batam is a substantial producer of an array of sophisticated electronics goods, with exports topping US$1 billion a year; it has modern hotels, fast food joints and supermarkets, movie theatres and banks, and an international airport that can accommodate 747s.

In the 1980s, the Southern Growth Triangle – linking Singapore, the Indonesian Riau islands and the Malaysian state of Johor – was but a gleam in the eyes of the political leaders of the three ASEAN countries. The concept was first promulgated only in the late-1980s, but today it is a reality, a potential economic 'ecological zone' nurturing the prosperity of three countries. The fulfilment of the concept is evidence both of how far the region has come since the unsettling days of the mid-1960s, when Indonesia was in Confrontation with both Malaysia and Singapore, as well as a tribute to President Suharto's far-sighted leadership in nurturing cooperative links between the nations of the region.

Batam's transformation from remote fishing hamlet to industrial capital of Indonesia's Riau province is also, in no small measure, the result of the regional business focus of a publicly-listed subsidiary of ST, Singapore Technologies Industrial Corporation (STIC).

ST's drive to fan out overseas as a matter of deliberate strategy began in the mid-1980s. With the Singapore economy having bounced back following a recession in 1985/86, local companies rapidly found themselves running up against rising costs and labour shortages. By 1988, the limits to the expansion of domestic operations were becoming clear.

But while many Singaporean companies had branch offices scattered across Asia, few had any experience doing major projects in the region. There were plenty of deterrents: the dearth of physical infrastructure in the region, uncertain and often opaque economic and political systems, and the temptation to stay put in Singapore's well-ordered and comfortable environment.

Philip Yeo, who was Chairman of STIC in 1989, recognised, however, the necessity of moving beyond Singapore. If the company was to grow, it simply had to venture out, notwithstanding its inexperience. In 1986, moreover, the group as a whole had identified the international market and overseas ventures as one of its four strategic thrusts.

STIC put its reputation on the line by promising to complete and power-up the first Batamindo Industrial Park (BIP) factory within 12 months. It did precisely that. A project of such scale and complexity would normally take one-and-a-half to two years to complete.

And if there were no readily available opportunities, it would have to create them, leveraging whatever strengths it possessed.

From what Yeo could see, the competencies which STIC had developed, and which could be transplanted quickly in the region, were construction, logistics and project management services. He decided therefore to take the group into the business of building industrial parks.

But developing a few hundred hectares of land outside an urban zone, and equipping the park with reliable and efficient infrastructure that would make it a haven for MNCs, was a relatively novel concept at the time. Nobody in Asia, at any rate, had produced an industrial park by world-class standards. A Singaporean company, however, could bring to the task a certain credibility. After all, Singapore had built up its own excellent industrial base virtually from scratch. But replicating the process in another country, in the face of logistical problems and in an environment controlled by others, was another matter.

And sure enough, STIC stumbled in its early efforts at industrial park building. In 1988, the company began work on the 80-hectare Ayudhya Industrial Park, 50 km outside Bangkok. In less than a year, STIC pulled out of the venture when it discovered that its strategy did not fit in with that of its Thai partners.

Undeterred by the Thai experience, STIC moved on to China. There, it negotiated for a piece of land and managed to get 1,000 hectares near Shanghai. But the project was short-circuited in the wake of the Tiananmen Square episode of June 1989. STIC would return to China later.

The move to Indonesia began in March 1989 when the Indonesian Ambassador to Singapore dropped in to see Yeo. "Mr Yeo", the Ambassador said, "I understand you are looking for a site overseas. Can I take you to Batam?" Yeo's first reaction was to ask, "Mr Ambassador, where is Batam? I've never been there in my life."

Yeo decided to bounce the idea off Dr Goh Keng Swee – the very same man who way back in 1960 had made the decision to drain the swamplands off the southwest corner of Singapore and establish Jurong Industrial Estate. Sceptics had referred to Jurong then as "Goh's Folly", but it turned out to be "Goh's Full House". When Yeo went to see Dr Goh in April 1989, the lion of Singapore had already retired from high political office, but he still had a hand in the economic policy making machine as Deputy Chairman of the Monetary Authority of Singapore (MAS) and Deputy Chairman of the Government of Singapore Investment Corporation (GSIC). He was like a friendly "guardian angel" of the Singapore economy, according to Yeo, and kept an open door to those who might want advice and ideas. His protege, Philip Yeo, was especially welcome. But Dr Goh was unenthusiastic about Batam. "You're crazy", he told Yeo. "I went there in 1975. It will never work." But Yeo pressed his case. It sounds like things on the island have changed, he suggested. In any case, there was no harm having a look.

A couple of months later, the two of them, Yeo and Dr Goh, were on the ferry headed for Batam. Things had indeed changed. As a result of the visionary leadership of Professor Dr B J Habibie, Indonesia's State Minister for Research and Technology, the Indonesians had already done a great deal to develop Batam and the other islands in the Riau province. They felt that Batam island especially had potential as a manufacturing base, not least because of its proximity to Singapore. They had declared Batam a duty-free zone and had begun to upgrade the island's infrastructure. "The roads were there, the port was there, and an airport too", Yeo remembered. There was also ample freshwater, and access to low-cost labour. The project was doable, Yeo concluded. Dr Goh agreed.

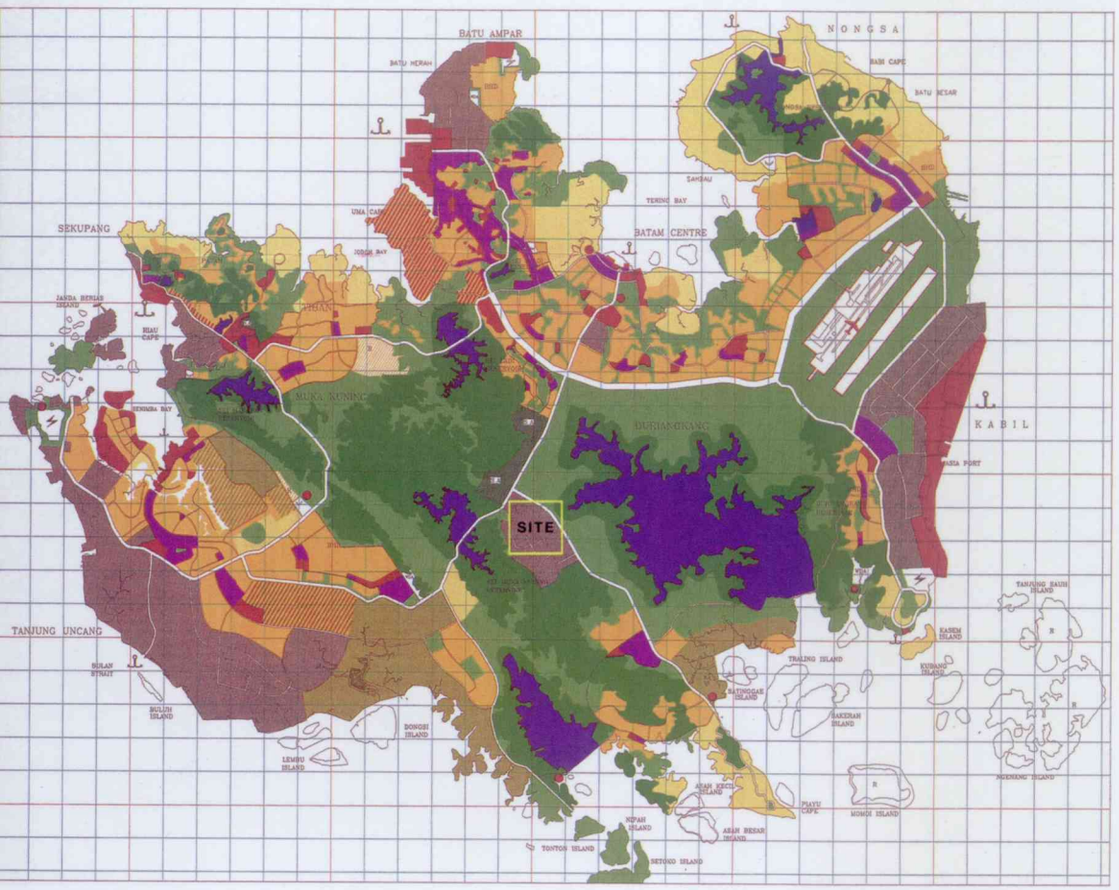
There were a few hurdles to get over, though. For a start, as a foreign entity, STIC could not own land in Indonesia; a local partner was needed. By August 1989, this problem was solved.

Wong Kok Siew

Wong has been part of the ST group's top management since 1983. He was the GM of its construction and financial services subsidiaries, and in 1989, he became President of what was then the newly-formed STIC. He successfully expanded STIC's operations into Indonesia, China, India and Myanmar, and organised the company's initial public offer in 1993. Wong is currently Chairman of STIC and Executive Chairman of Nomura Singapore. Prior to joining the ST group, he was the MD of Hunter Douglas's Singapore operations. Wong, a Colombo Plan Scholar, graduated from McGill University as an engineer, holds an MBA from McMaster University, Canada, and attended Harvard Business School's Advanced Management Programme.

Aerial view of the Batamindo Industrial Park. In less than four years after the ground-breaking, over 60 companies set up operations in the park.

Previous Spread
The BIP is strategically located at a crossroad junction which links the park to the seaport at Batu Ampar and the Hang Nadim airport.



A map of Batam island showing the various land uses, including housing, tourist resorts, industry, agriculture, reservoirs and green areas.

"Mr Anthony Salim had spent a week preparing a presentation for me, and he came to my office with a stack of papers", Yeo recalled, referring to the scion of Indonesia's biggest conglomerate, the Salim group. There was no need for the stack of paper, though. Salim and Yeo cut quickly to the chase, so to speak, and the deal was soon done. STIC, together with the Jurong Town Corporation, would partner the Salim Group for the project. The Indonesians would buy the land, source human resources, take charge of the local logistics and relations with government bodies; and the Singaporeans would develop, market and run the industrial park.

The vision was that the park would be a self-contained, hassle-free haven for companies. It would have factories as well as its own utilities, living areas and social amenities. Warehousing and transportation would be provided too, along with recruitment services, estate management, medical services, round-the-clock security and other administrative support. The total investment required was estimated at US$530 million.

Over the next few months, preparations got under way. The site was chosen: a 320 hectare area in the centre of Batam, two km from the largest freshwater reservoir on the island. In January 1990, the two companies that would execute the project were created: PT Batamindo Investment Corporation on the Indonesian side, and on the Singaporean end, Batamindo Industrial Management (BIM). The Salim group would have a 60 percent stake in the venture, and STIC 30 percent, with the rest being held by JTC International, a subsidiary of Singapore's Jurong Town Corporation.

A major problem, though, was financing. At the time, it was uncommon for banks in Singapore to extend Singapore dollar loans for overseas projects, and interest rates in Indonesia were running at a prohibitive 20 percent. Borrowing at those rates would have killed the project.

Dr Goh at MAS arranged for the go-ahead to be given for Singapore dollar-denominated financing. But the loans were difficult to come by. Local banks, with the notable exception of the Overseas Union Bank (OUB), proved to be overly conservative.

They had their reasons. For one thing, no feasibility study had been done. In fact, Yeo was convinced that had there been any, the project would have been found to be non-feasible. The idea that a tract of jungle on an obscure Indonesian island could be transformed within a year into an industrial park, tenanted by multinational companies producing high-tech products, was regarded by many, understandably perhaps, as absurd. Nor did STIC, or any other company in Singapore, for that matter, have a track record in executing a project of this kind.

The fact that STIC was a government-linked company served, if anything, to make the bankers even more doubtful. As the company's then President, Wong Kok Siew, told Singapore's *Business Times* in March 1993, the government link made people think that the Batamindo Industrial Park (BIP) was more of a political than a commercial venture. "You guys went in because it's national service", he recalled people telling him. "That was a lot of bull. We went in because we saw an opportunity."

But the impression was widespread; few were willing to back a so-called 'national service' project; getting the first loans for the project, therefore, proved tough. But eventually, thanks to the support of OUB and a few foreign banks, STIC was able to put together S$370 million. The project could now at least get started.

But in order to keep the stream of financing flowing, quick results were needed. So, even as the bulldozers and the building materials were being shipped into Batam, the hunt was on for prospective tenants for the park. The hope was that as tenants or buyers signed on and made advance payments, banks might become more forthcoming. This indeed was what happened. The second and third syndicated loans, which were arranged after tenants began to sign up, posed fewer problems. 'National service' had become good business.

The first company to show interest in the Batamindo Industrial Park was a joint-venture between Sumitomo Electric Industries and its subsidiary, Sumitomo Wiring Systems. The company was identified by Mr Swee Lay Sing who had been tasked by Yeo to market the park to Japanese companies.

From forest to factories.
Land clearing for the BIP.

On the 28th of February 1990, soon after the ground-breaking ceremony, Yeo escorted Mr Tetsuro Kawakami, Chairman of Sumitomo Electric Industries, around the site. At the time, the road leading to the area had only just been completed and little else was in place. Yeo told Kawakami, "I will build you a factory in this jungle, and I will have it ready within one year". Kawakami took him at his word. Nothing was put in writing; it was a gentlemen's agreement.

On April 30, the joint-venture company that Sumitomo Electric Industries and Sumitomo Wiring Systems had formed, signed an agreement to become the first tenant of the Batamindo Industrial Park. Soon after came the French electronics giant, Thomson Consumer Electronics, which chose the park as its site for manufacturing television tuners and remote controls.

Construction work on the site soon got underway. The logistical hurdles were daunting. Virtually everything had to be brought in from Singapore, from earth moving machinery to the smallest of tools.

Putting the utilities in place proved to be a major challenge. The STIC management was insistent that these be not merely functional, but as reliable as those in Singapore. Given enough time, this was feasible. But STIC had made a commitment to have the park up and running within one year.

Organising the water supply was relatively straightforward. A pipeline was laid to the nearby reservoir and a 2,500 cubic metre water purification plant was built to produce potable water. The sewage treatment facility was also built with no hitches. Setting up the telecommunications network was more complicated. It had to be done virtually from scratch because Batam had no international telephone system. While a microwave transmission facility was being built, STIC arranged for temporary communications via Singapore for outgoing calls. Incoming calls were routed through Jakarta and Medan.

By 1991, however, a world class telecommunication system with IDD facilities and 3,000 lines was ready. When Mr Goh Song How became Managing Director of BIM in September of that year, his first international call was to the headquarters of Sumitomo in Osaka. "Hello", he said, "I'm calling you direct from Batam."

The biggest problem, however, was the power supply. A full-fledged power-plant for a facility the size of the Batamindo Industrial Park normally takes at least 18 months to build. How could power supply be brought on stream within 12 months?

Again, STIC resorted to some improvisation. While building a high-efficiency diesel power plant, it bought two 17-year old gas turbine engines from Singapore's Public Utilities Board, had them refurbished and installed them in Batam. But even that could not be done in time. So when the first two tenants moved in, just 9 months after construction of the park had begun, BIM rented two 750 kw diesel generators and parked them beside their factories. "For three months, we ran those generators exclusively for the two

tenants, and for the same price we had agreed to charge them", said Goh. "The tenants didn't have to pay any premium."

"Today, if anybody asks me to build an industrial park, I'll never say I can do it in twelve months. I'll say two years, or at least 18 months", Goh added. "But at that time, we had committed ourselves to a tough schedule and we just had to do it. A promise is a promise. Our reputation was on the line." By March 1991, Sumitomo's wiring and harness factory was up and running, eleven months from the time it had signed up to be a tenant. Thomson had started production a month earlier.

As the months passed, more tenants came. The Swiss medical and pharmaceutical giant, Ciba-Geigy, decided to locate a subsidiary, a producer of contact lenses called CibaVision, in the Batamindo Industrial Park. The British bulk bag manufacturer, Bowater PLC, chose the park as the site for its first manufacturing facility in the Asia-Pacific region. Honfoong Plastics, a Singaporean company producing plastic injection mouldings, had its first factory in the BIP operational in just eight months. It subsequently bought a second factory. Over 1992-96, the BIP became home to the subsidiaries of a string of blue-chip corporate names, including Asahi, AT&T, Epson, Foster, Fujitec, Asia Matsushita, Kyocera, Sanyo, Siemens, Seagate, Quantum and Nikon, among others.

G Arumugam

After a career in Mindef, Arumugam joined PT Batamindo Investment Corporation in 1992 and was appointed Chief Operating Officer of the Batamindo Industrial Park. As Chief Operating Officer, Arumugam was responsible for the operational management of the park. During his tenure, the park became the first integrated industrial estate in the Asia-Pacific region to receive the ISO 9002 certificate. Apart from the day-to-day running of the park, Arumugam had to make time to administer to the welfare and recreational needs of more than 55,000 park workers. In 1996, Arumugam was awarded the Best Executive Award by the ASEAN Programme Consultant, an Indonesian consortium. Arumugam retired as the GM of PT Batamindo Investment Corporation in 1997, but continued to serve as its Consultant.

A 100-metre high communications tower, equipped with microwave transmission and receiver systems, provides the BIP with communication with the rest of the world.

Opposite Page
The BIP's own water treatment plant has a capacity to treat 2,500 cubic metres per day – each drop in strict compliance with World Health Organisation standards.

As of the end of 1996, a total of 84 international companies were operating in the Batamindo Industrial Park. Forty-one of them were from Japan and more than half were in the electronics business. The park generated more than US$950 million worth of exports during the year, a figure that is expected to jump to US$1.5 billion by 1999.

Because of the unique nature of the BIP, the Indonesian government adopted a flexible system in the administration of the island through the Batam Industrial Development Authority (BIDA). Recognising that speedy responses would be critical in building confidence among international investors, BIDA provided a fast-track authorisation of development and infrastructure plans submitted by the BIP. BIDA extended the same spirit of co-operation in the areas of licensing and permits, immigration and customs, and human resources.

The dynamic pace of the park's development also owed its success to two other bodies – the Economic Development Board (EDB), which represented the Singapore government in government-to-government relations concerning the project, and the Indonesian Embassy in Singapore, which played a highly committed and supportive role. The BIP also benefited from the enlightened approach of Professor Dr B J Habibie and Mr Tunky Ariwibowo, Indonesia's Trade and Industry Minister, towards regional cooperation.

Despite its hectic industrial activity, the park now resembles a quiet, orderly suburb, with wide tree-lined avenues and neatly trimmed lawns. It is a self-contained mini-township, with its own social amenities, including a food centre, schools, sports and games facilities, a wet market, restaurants, a supermarket and provision stores.

The Batamindo Executive Village, developed by STIC in partnership with five other companies, is a fifteen-minute drive away from the park. An enclave of luxurious condominiums and bungalows, the village includes the stylish SouthLinks Country Club, which has a Japanese-designed 18-hole golf course as well as facilities for swimming, tennis and high dining.

The Batamindo Industrial Park was a commercial success well before expected. It started to return profits within three years of its establishment, compared to a norm of five to seven years for a project of its kind. Even Philip Yeo was surprised.

The park is now being expanded. In April 1996, the groundbreaking for a new phase took place. This will cover 30 additional hectares, and will provide for more factories, dormitories and recreational facilities. Meanwhile, a four-storey shopping complex with two cinema theatres is being built near the headquarters of the Batamindo Investment Corporation at the edge of the park. This project is expected to be completed by the end of 1997.


BATAM
INDUSTRIAL
P A R K

An aerial view of utilities, factories and dormitories in the Bintan Industrial Estate.

With plans for still more commercial and social amenities on the drawing board, the BIP is poised to grow, in the years to come, into not only a major manufacturing centre in Indonesia's Riau province, but a prosperous and bustling commercial township, something far beyond what STIC had envisioned when its construction teams first started clearing the jungle on the island back in 1989.

Batam is the first, but not the last, example of how mutually supportive economic cooperation among the countries of the region can nurture growth, which, like the rising tide, will lift all boats – Indonesian as well as Singaporean.

In August 1990, soon after the first tenants began to move into the BIP, a landmark Economic Cooperation Agreement was signed between the governments of Singapore and Indonesia to promote and protect investments in the Riau islands. The idea was that while the governments would provide every assistance, private companies would spearhead the development of the region.

With the Batam venture now well on its way, STIC turned its attention to possibilities on the biggest island in the Riau province. This was Bintan, which lies 50 km to the south-east of Singapore. Over 1990 and 1991, teams from STIC made a number of exploratory trips to the island. Their investigations pointed to two possible projects: one was an industrial park similar to the BIP; the other was a major tourism project.

In 1991, STIC teamed up again with the Salim Group and JTC International to set up the Bintan Industrial Estate (BIE). Construction work on the project began in early 1993. The land was cleared and the infrastructure – the roads, the power station and the telecommunications facilities – were built.

By the end of 1996, some 100 of the 4,000 hectares estate had been developed, and 11 companies were operating in the park. These included manufacturers of garments from Indonesia, Singapore and Taiwan, as well as more technology-intensive operations, like a precision machining plant.The BIE is now positioned to be the site for a diversified range of industries, and in time, it may develop into one of Indonesia's biggest export-processing zones.

In the meantime, another part of the island was developed into a world-class holiday resort. On Bintan island's northern shore there is a 30 km stretch of pristine and picturesque palm-fringed beach that lay undiscovered until the 1990s. In 1991, STIC conceived the idea of transforming this unspoilt tropical paradise into a tourist resort with luxury hotels and a range of sporting and other recreational amenities. The plan was to develop an area of some 23,000 hectares, while retaining as much as possible of the island's natural beauty.

To execute this massive project, STIC joined hands with blue-chip partners: Indonesia's Salim Group; the Kintetsu Group, one of Japan's largest travel companies; Straits Steamship Land, part of Singapore's Keppel group; Tropical Resorts; and the 'Big Four' Singapore Banks.

The consortium began work in November 1991 on the Bintan Beach International Resort project.

In February 1996, the first resort, incorporating a golf club and hotel, opened for business. This was the Bintan Lagoon Golf and Beach Resort, jointly owned by SAFE Enterprises (an STIC subsidiary), the Salim Group, the Kintetsu group, Straits Steamship Land and Temasek Holdings. By the end of 1996, a number of hotel developers had leased beach-front land on Bintan to build resorts, including Wah Chang International, the Mandarin group, the Shangri-la group and Club Med; and five resort hotels were already operational on the island.

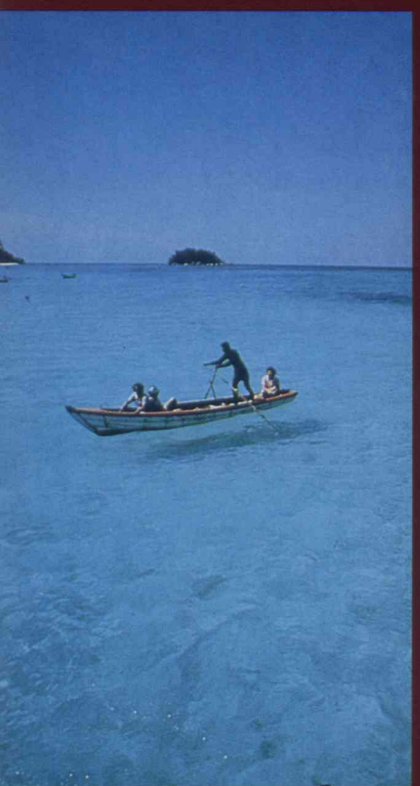
It is expected that when fully developed, the Bintan Beach International Resort will offer holiday-makers from the region attractions that include nature trails, coral gardens, marinas, amusement parks, street bazaars and equestrian centres. It could well blossom into one of Asia's biggest and most magnificent beach resorts.

Goh Song How

Goh joined STIC in 1991, and now wears a number of hats in the company. He is its Executive Vice President, the Chief Executive Officer of various STIC overseas infrastructure companies, as well as MD of ST Construction. A Colombo Plan Scholar, Goh graduated in 1975 from Newcastle, Australia, with an Honours degree in Civil Engineering and an arts degree majoring in Economics. He is a registered professional engineer and also possesses a Master's degree in Construction. Goh joined Mindef in 1976 and was responsible for its construction and infrastructure development projects for over 15 years.

Bintan boasts quality industrial facilities as well as the beautiful and luxurious Hotel Sedona, and the Bintan Lagoon Golf and Beach Resort.

Keeping Bintan Green



For lovers of nature, Bintan is a treasure trove. It is rich in flora and fauna and the waters off the golden beaches to its north are inhabited by hundreds of varieties of sea-plants, fish, marine animals and coral reefs.

While developing the island into a resort, STIC did its best to preserve nature's heritage. Bintan Resort Management Pte Ltd (BRM), the STIC subsidiary that manages the resort's development, employed two full-time environmentalists as part of a larger Resort Planning team which consisted also of engineers and planners. The team worked with developers to help ensure sustainable development.

The involvement of environmentalists was no afterthought. Indonesian law required an "environmental impact assessment" to be done on all of the Resort's 23,000 hectares before construction work could begin. BRM's environmentalists, Mr Andrew Young and Ms Charlotte Caffrey, worked with external consultants on this major undertaking. They went beyond the legal requirements: for example, environmental assessments were undertaken for each land parcel and even on specific areas within parcels where necessary.

This attention to detail enabled BRM to advise investors on environmental issues relating to their developments. It also facilitated the establishment of guidelines on eco-friendly development – for example, on the route and shape of roads, the height of buildings, how far from the sea construction should be, how golf courses should be best constructed; and most importantly, which areas should be designated as 'greenbelts' and thus left intact as sanctuaries for wildlife and indigenous species of plants.

"What will make the difference in Bintan will be our ability to integrate development with concern for the environment,'' said Mr Yeo Nai Meng, Chief Executive of BRM. "In many resorts, environmentalists begin their work after development has already taken place. In such cases, the environmentalist's job is rehabilitative in nature, correcting all the mistakes made during the development, and often, he or she ends up working more as a horticulturist than anything else. In the case of Bintan Resort, the focus is not so much on corrective action as it is on working together with developers to ensure that development is sustainable, both economically – so that investors get value for what they buy – and ecologically."

Yeo stressed that for Bintan Resort, environmental concerns must make business sense. "We cannot say to investors: 'please buy a piece of land here, but we're sorry you can't do anything with it.' We have to show them what they can do. In the end, we have to come up with a product that our customers – investors as well as tourists – find desirable. Therefore our environmentalists have to contribute to development, not work as policemen."

So what sort of work do BRM's environmentalists do? They helped to moderate the gradient of slopes on the sides of roads to better regulate drainage. They also advised on the routes of roads. In one case a road that was to run through a freshwater swamp containing two indigenous species of fighting fish, was redesigned so as to avoid certain areas of the swamp. "If we hadn't

done that", Young explained, "the two species of fish would have become extinct."

The environmentalists also advised developers on the sewage treatment plants to install, to ensure that effluent water was so treated that it could be recycled for use in irrigation and landscaping. Bintan Resort's sewage treatment plants comply with World Health Organisation guidelines on effluent discharges.

BRM's environmentalists also helped in the construction of golf courses. In one case, an environmental impact study revealed that the use of fertiliser at one particular hole could have damaged the algae and other marine life along the coast, and the course was redesigned as a result. A biofilter was also installed to remove damaging nutrients from the fertiliser before they were discharged into the sea.

BRM's environmentalists also helped with efforts to educate visitors about Bintan Resort. They developed nature trails and mangrove swamp tours, and have drawn up guidelines for boating and fishing on the island.

Caffrey has also co-authored a book, *The Underwater Guide to Bintan*. It documents the rich variety of coral, fish and other marine life found off the island, and provides pointers on underwater photography. "The idea was to show people what's there, so they'll appreciate it", she said. "Also, we wanted a snapshot of time so we have a historical record. We'll keep monitoring the Resort's underwater life, and if that record changes, we'll know something has gone wrong."

The environmentalists also regularly test the quality of the water close to the shore, to check whether it is clean enough for swimming; they keep tabs on water currents and the quality and diversity of the coral reefs around the island; and they check the composition of the effluent discharges of the sewage treatment plants.

In the future there will be new techniques for eco-friendly development which will have to be understood and harnessed. Other parts of Bintan will also be developed, and the natural as well as socio-economic effects of this development will have to be studied and dealt with. At no point, however, will the work of environmentalists at Bintan Resort ever be finished.

As Yeo declared, "it's one of those never-ending jobs."

Venturing Further Into The Region: The Wuxi-Singapore Industrial Park

The assembly line at the Korea Electronics Company (KEC) factory in WSIP. KEC manufactures semiconductors.

The success of the Batamindo Industrial Park helped give STIC the experience and the confidence to develop more projects of that nature. In 1992, therefore, the company began to explore options further afield, in Asia's biggest market – China.

At the time, the booming Chinese economy was the largest recipient of foreign direct investment among all developing countries. However, close to 70 percent of this investment came from Hong Kong and Taiwan. A number of Japanese and Western corporations, although enthusiastic about moving into China, were deterred from doing so by uncertainties concerning infrastructure, logistics and bureaucratic and administrative hurdles.

For STIC, this spelt an opportunity. After a few exploratory visits and a feasibility study, it decided, in December 1993, that it would go ahead, and it formed a consortium with JTC International, Temasek Holdings, the KMP group and the Economic Development Group Corporation of the Wuxi Municipality.

For the site, STIC chose a ten sq km area 20 minutes by car from Wuxi, a city of 4.2 million people in China's Jiangsu Province. Wuxi has many advantages. First is location: it is situated in the belt between the major cities of Shanghai and Nanjing, economically, one of China's fastest-growing regions. It is just 130 km from Shanghai, yet without Shanghai's high labour and real estate costs. And Wuxi's local government, a part of the consortium, is strongly pro-business, progressive and outward looking.

Moreover, unlike Batam or Bintan, Wuxi was already a thriving industrial centre with a reasonably well-developed infrastructure when STIC moved in. It is one hour's drive away from the port of Zhangjiagang, and has good road, rail and air links with both Shanghai and Nanjing. It was earmarked as a high-technology area by China's central government in its eighth five-year plan, and contains a number of renowned educational institutions.

However, building and running the Wuxi-Singapore Industrial Park (WSIP) posed a host of challenges. For a start, the site chosen, unlike in Batam and Bintan, was not virgin jungle, it was farmland. The existing tenants had to be resettled, a problem that was resolved quickly by the local government.

Construction also had its complications. Given China's relatively high import duties, STIC had to rely heavily on locally available material. "We could not afford to import everything," said Goh Song How, now STIC's Executive Vice President, who personally took charge of the project. "So we were forced to compromise in some areas. But we did not compromise on safety or on automation systems." STIC had to depend on local contractors, plus deal with China's legendarily complex provincial bureaucracy.

In addition, unlike in Batam and Bintan, STIC faced stiff competition in Wuxi. There were already a number of other industrial parks in the area, some of them offering cheaper, although more rudimentary, facilities.

The WSIP was also up against similar facilities in other parts of China. As Goh pointed out, "When foreign investors explore production sites in China, they don't look only at Wuxi; they look at sites in cities all over China, and they have at least one thousand choices."

The marketing challenge in the case of the WSIP was therefore tougher than STIC had ever encountered before, and so it went about the job aggressively. It organised seminars in Beijing and Shanghai, and roadshows in Japan, the US, Europe and, of course, Singapore itself.

The park was targeted at investors in high-tech industries – notably electronics, telecommunications and precision engineering. Although the facilities offered were more expensive than some of the competing local industrial parks, they were by far the best and most comprehensive available in the area. The WSIP's infrastructure included wide, well-paved roads, round-the-clock water supply and electric power, cargo collection, sewage disposal and telecommunication services reputed to be among the best in China.

Supporting services included security, recruitment services, transport for the distribution of goods to other parts of China, plus liaison with local banks, tax and customs authorities, as well as with government agencies responsible for licences and permits. Workers at the WSIP were provided with dormitories, training, recreational facilities and medical services. Condominium-style private housing for expatriates was available within a half-hour's drive from the park, and an international school was also established.

Tay Siew Choon

Tay Siew Choon first joined the ST group in 1985 as GM of Singapore Computer Systems (now ST Computer Systems & Services). He has held several management positions within the group, and in 1995 became President of STIC. He is also concurrently the MD of Singapore Technologies Pte Ltd, as well as a director of Pidemco Land and other ST companies. Tay has a BSc in Electrical Engineering from Auckland University, New Zealand, and an MSc in Systems Engineering from the University of Singapore. He served in the SAF and was the Executive Director of a publicly-listed group involved in manufacturing, trading and property development prior to joining ST.

The City of Three Kingdoms Theme Park in Wuxi. One of the ten most visited cities in China, Wuxi has attractive accommodations as well as shopping, food and leisure facilities.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Previous Spread
Driving forward. The 312 Highway from Wuxi leads to the Huning Highway. Shanghai is towards the east, and Nanjing is towards the West.

Opposite Page
The clean room in Seagate Technologies' WSIP plant.

Manufacturing pneumatic fittings at Legris' WSIP factory.

The first tenant to start production was Seagate, the US disk-drive manufacturer, which came on board in July 1995, and subsequently found that its Wuxi plant was one of the fastest startups in its history. It is now expanding its operations in Wuxi. Sumitomo Electric Industries, which had set up a plant in the Batamindo Industrial Park, decided to establish another one in the WSIP as well. In April 1994, it established a subsidiary in Wuxi to manufacture magnetic wires, and was rewarded, for the second time, with an operation that got off the ground quickly and smoothly.

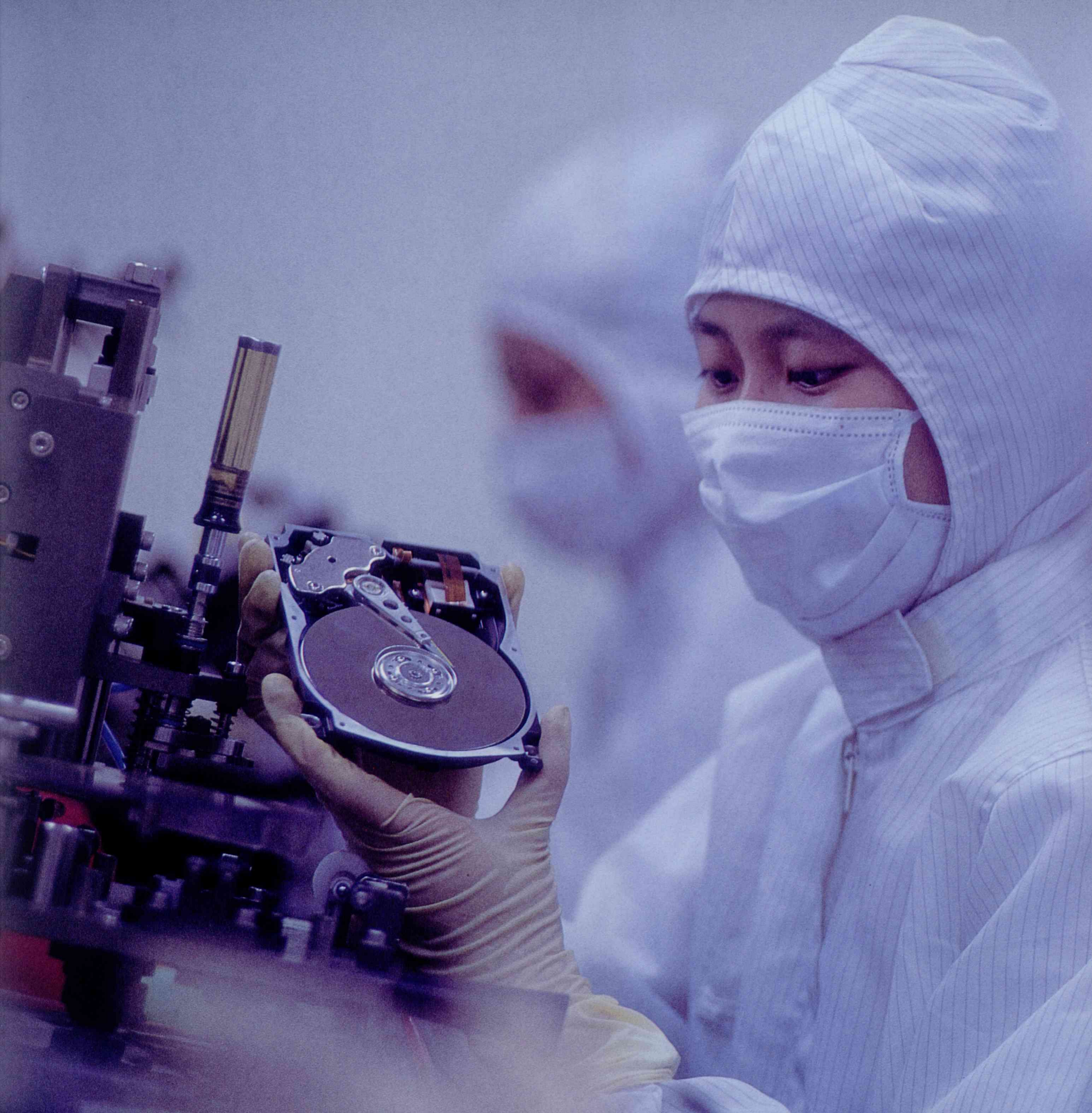
Several other firms involved in high-tech businesses – including Matsushita Refrigeration, Alps Electric, Legris, Hitachi-Maxell, Siemens Components and Polor Cup Packaging – also set up plants in the WSIP. By the end of 1996, 36 companies had investments totalling US$430 million, and 21 of them had already begun production. The park was able to turn a profit in the second year – again, an unusual achievement for a project of its kind.

As in Batam and Bintan, the success of the industrial park in Wuxi owed much to its one-stop shop concept: companies were attracted by the prospect of being able to move to a low-cost production site and concentrate on doing what they do best without having to cope with infrastructural, logistical and administrative problems.

STIC's ability to create such an environment was now solidly established. It had developed a strong capability in areas such as prefab technology, logistical management and construction. It had also mastered the trickier aspects of the business, especially the management software that goes into running an industrial park: anticipating what investors need; ensuring that everything runs smoothly round-the-clock; bridging cross-cultural differences between companies from around the world and local people; and ironing out difficulties with local authorities.

In 1997, STIC President Mr Tay Siew Choon said that the company was moving into the business of 'primary' infrastructure – constructing facilities such as waterworks, tunnels, bridges, highways and power-stations – the demand for which was soaring in Asia. In China alone, STIC is now exploring projects that could be worth US$500 million between 1998 and 2002. In the area of leisure, too, STIC is thinking far ahead. Besides developing the northern coast of Bintan into a full-fledged resort belt, other projects will include the launching of a chain of cinemas across China in 1998. STIC is also exploring food-processing ventures throughout Asia.

Tay said STIC's main focus areas – industrial parks, infrastructure, lifestyle, leisure, and information technology – will fit together over the long haul. "Industrial parks are entry points into a country. After that, infrastructural investments gain in importance. And then, as employment is created and wealth spreads, the demand for leisure activities grows. Also, as the economy grows, the need for IT as a form of modern infrastructure will increase." STIC, he maintained, has to aim high. In 1996, STIC's post tax profits rose 22 percent to S$66.5 million, making the company one of the star performers in the ST group.



Singapore Inc Sprouts Wings

Ever so rarely, there emerge countries that acquire a degree of economic clout out of all proportion to their size or natural wealth. Their names resonate way beyond their shores, and down the corridors of history: Venice, Spain, Portugal, Holland, England. With the end of colonialism and with more nations entering the race to succeed, it has become harder for small nations to establish themselves as global players. And yet there is Switzerland, one such undersized power, and Korea and Taiwan are well on their way. And sometime early in the next century, Singapore might just join the list.

In one generation, this island of three million people has transformed itself from a third world entrepot to an economic powerhouse. But Singapore, which was written off as a no-hoper in the 1960s, does not feel that it has arrived. Its leaders, acutely aware of the intensifying competition in the region and around the world, believe the treadmill underfoot is now moving faster and Singapore has to run harder in order to stay in the same place. Never one to sit back, the country is ever on the lookout for new opportunities to seize, new niches to carve. Thus its regionalisation drive.

Having built up a wealth of expertise in many areas, as well as the financial muscle to match, Singapore has to go beyond its borders in order to keep flying high. Its economy needs a second 'external wing', as the country's leaders put it.

There is a strong economic rationale for going regional. For decades, Singapore has saved more than it has invested domestically. Today, its savings rate stands at a world-beating 50 percent of GDP, and its investment rate at more than 30 percent. These have contributed to a string of external current account surpluses, which have been further augmented by capital inflows. Foreign direct investments are pouring in – in 1996, the haul topped US$6 billion – and lately, there have been huge monetary inflows as well. With foreign reserves of more than US$70 billion, the country's resources are running far ahead of what the domestic economy can absorb.

These surpluses have to be channelled overseas. The focus on Asia is a logical choice. Singapore has ethnic and historical links with nearly all countries of the region. Asian economies are booming, and intra-Asian trade is rising rapidly. There are bright prospects for many activities in which Singaporean companies have an expertise: among them, labour-intensive manufacturing, shipbuilding and shiprepair, banking, real estate development, hoteliering and a range of infrastructure-related activities.

There are other reasons to regionalise: mature Western economies are prone to periodic recessions, and trade frictions have fuelled fears of protectionism. Ever pragmatic, Singapore wants to hedge its economic bets and reduce its dependence on North American and European markets.

By the end of 1994, the small island's stock of foreign direct investment had reached US$37 billion. More than half of this is in Asia. Singapore is among the top five investors in Indonesia, Malaysia, Myanmar, Thailand and China. Singaporean conglomerates like Keppel, Singapore Technologies

and Sembawang are receiving increasing proportions of their earnings from overseas operations. In Singapore Technologies' case, overseas operations accounted for about 14 percent of its total revenue in 1996. For the country as a whole, income from abroad in 1995 amounted to S$15.4 billion, or 13 percent of its GDP.

In China, Singapore companies are participating in scores of projects, ranging from farms to full-fledged technology parks. Besides the ST-led industrial park in Wuxi, Singapore's flagship project is a 70 sq km industrial township near the city of Suzhou, which will support a population of 600,000 when it is completed in ten years' time. The media has dubbed it "Singapore Two".

In India, Singapore projects include an international airport in Bangalore, township developments near New Delhi, gas terminals off Bombay, and a port near Madras.

Singaporean companies are also pushing into Thailand, Vietnam and Myanmar. In Malaysia, Singapore's top investment destination, the stock of Singaporean investments is close to US$4 billion.

Apart from investing directly in the region, Singapore is also positioning itself to take advantage of Asia's boom in other ways. For example, it has set itself up as a base for pilot production and prototyping. International companies, planning to launch new products and services in Asia, can do their product-testing and test-marketing in Singapore before venturing into the region. With its world class physical and financial infrastructure, and the relatively high skills of its workforce, Singapore is also well placed to be a hub for coordinating business activities in the region. It can become a centre for activities like corporate planning, training, sourcing, purchasing and financial management.

To keep its regionalisation drive in high gear, Singapore has pulled out all the stops. Its government offers a slew of tax breaks and financial and training assistance to companies venturing overseas. Key official agencies associated with regionalisation have set up offices all over Asia. And Singapore has signed investment protection and tax agreements with a number of Asian governments.

By the start of the next millennium, therefore, Singapore Inc could be a big player in Asia, and the ST group, a recognised name in the region.

Seagate Technologies' Wuxi Plant.


Singapore
Technologies

CHAPTER FIVE

UNDER ONE SUN

Three decades of relentless growth produced a collection of fiercely independent companies. The task of coordinating this diverse collection, without losing the advantages of independence, was to be an abiding concern of the group's top management, and prompted periodic corporate reorganisations. Along the way, the group also listed many of its entities on the Singapore Stock Exchange, divesting itself of its image as a wholly-owned government company. And in 1990, in what was to be a watershed event, Sheng-Li Holding was renamed Singapore Technologies Holdings to affirm the new corporate identity launched in 1989. As a name, Singapore Technologies signified a common identity; and as an organisational concept, it enabled the group to grapple effectively with questions of coordination and strategic direction.

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UNDER ONE SUN

One keeps forgetting to go right down to the foundations.
One doesn't put the question marks deep *enough down.*

Ludwig Wittgenstein

In the corporate headquarters of Singapore Technologies at Science Park, there hangs a framed collage of cards. A closer look reveals ordinary business cards bearing a variety of names and logos: Chartered Industries, Sheng-Li, Singapore Technology Corporation, and so on.

It is not a particularly prepossessing piece of interior decoration, compared with the shiny commemorative plaques, mementoes and artworks around that are the staple of corporate furnishings. But in the 30-year history of ST, the cards are important archaeological relics – reminders of the string of corporate identities that the defence industries and their commercial off-shoots adopted at one time or another.

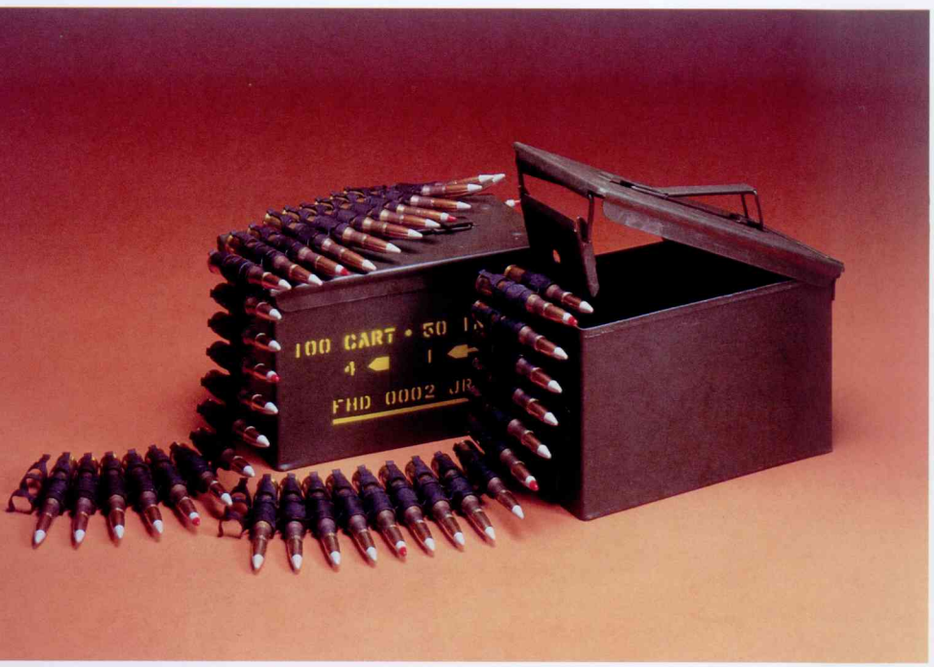
Indeed, nobody who looks at the past of Singapore Technologies can fail to miss the almost bewildering frequency with which the group of companies renamed and reorganised themselves. The story of ST is not only one of new products and processes, exciting ventures and bold experiments. It is also one of constant introspection and re-invention.

This corporate restlessness was not the result of any chronic indecision among the group's leaders, but a natural outcome of its peculiar mission. From the start, the special nature of the defence industries meant that the issues of ownership, control and corporate structure were as critical as the question of products and markets. The companies had to be configured in such a way as to meet unique strategic needs without compromise but also without pouring public funds down a bottomless pit.

Among the key questions that arose were: Where on the continuum between government and the market should the group operate? And later, as the group expanded and diversified: How to maintain the creativity of autonomous business units while tapping the synergy of the whole group? When to expand the portfolio, when to divest?

The questions were persistent, and the answers often required major reorganisation and restructuring of the group. These did not promise any permanent fix, but at best the hope of maintaining a dynamic equilibrium that would keep the group productive and profitable – until it was time for the next round of introspection.

SunPage, the network service of ST SunPage, offers paging and advanced messaging services. ST's reputation for technical expertise and its ability to develop networks and provide services quickly, will help SunPage compete effectively in the newly opened messaging services market.



Machinegun rounds. Domestic defence industries can generate spin-offs for a nation's economy. Being capital intensive, they can help develop the scientific and technological base, improve overall skills and labour productivity, and stimulate general industrial growth. Engineering competencies in defence technology often spill over to benefit civilian industry.

A Commercial Footing

As we saw in earlier chapters, the sudden and traumatic independence of Singapore in August 1965 provided the *raison d'être* for indigenous weapons manufacture. But defence needs in themselves did not dictate what kind of organisation should do the job. As Dr Goh Keng Swee noted, "the Government had the choice of establishing a conventional arsenal, producing for its military needs only, selling on a cost-plus basis. [Instead] it was decided that production should be undertaken by a state-owned enterprise working on commercial principles, charging the Defence Ministry a price no higher than that of a foreign good."

That choice may seem somewhat undramatic. In fact, however, it was a move without which ST would not have evolved. BG Lee Hsien Loong explained the significance of what he called the "crucial decision" to set up Chartered Industries as an independent corporate entity:

> CIS established the model for all the other defence companies which followed. The easier path would have been to do it in-house, and establish an ammunition arsenal or ordnance foundry within Mindef. This would have been less risky, at least from the point of view of CIS. As a non-commercial operation, the arsenal would have been shielded from competition, operated on a cost-plus basis, and would have had no problems filling its order books with SAF business.

Guns and butter. Those who studied economics in pre-university may remember the "guns or butter" chart – how the more you spend on one the less you can spend on the other. In actuality, the two are not incompatible. Food, for example, is of vital logistical importance to the military, but civilians also eat. In its early days, SFI focused on providing for the SAF, and in the process acquired extensive warehousing, distribution and food processing skills. It now exploits these skills in the commercial 'civilian' sector.

Instead, CIS became a company run on commercial principles. Mindef established a commercial relationship with these defence companies. Far from guaranteeing them a captive market, it required them to bid for Mindef work in competition with other defence manufacturers, usually against foreign suppliers. CIS managers and engineers thus had the freedom and flexibility to operate unencumbered by bureaucratic red tape, with a firm eye on the bottom line and the right to retain and reinvest surpluses earned.

This gave them strong incentive to maintain a lean and efficient operation, and deliver good service to the SAF, saving it millions of dollars in ammunition and weapons costs. Indeed, it forced them to do so. CIS developed export markets for its products, satisfying its customers that it was more than competitive in terms of price, quality and speed of response and delivery. They did so without any government subsidies, in a business where "fair" trade is a meaningless term, and nearly every foreign supplier enjoys some privilege, hidden or open, from its home government.

Lim Ming Seong put the difference between the private and public sectors in simple and graphical form: "In government, you are given a budget and your objective is to come within budget. The more money you save, the better. Whereas in a company context, you are given a budget of one dollar, the idea is not to come back and say, 'I have only spent 80 cents, I saved you 20 cents', but the challenge is,'I spent the $1, but in the process, I made $1.20'. So it's a different mindset."

Chua Su Li

Chua, the Company Secretary, has been with the group for the last 20 years. An institutional memory of ST, she joined Sheng-Li in 1976, her second job after graduation. Back then, ST's subsidiaries numbered less than 20, and the Sheng-Li office comprised less than ten employees, from the Chairman to the driver. Chua recalled those early days with fondness, especially working with Sheng-Li's first Chairman, the late Ong Kah Kok, and the first MD, Kua Hong Pak.

"We were a closely-knit team. There was a spirit of camaraderie and friendship from the Chairman to the clerk, due to the fact that we worked so closely together. Our office was in Harding Road, off Tanglin Road, just a stone's throw from the old Mindef complex. I remember that every now and then Kua and Ong would be summoned to see Dr Goh. Every time they returned from such meetings, there was always a sense of urgency to get things done."

Lim Siong Guan

Lim, Permanent Secretary, Prime Minister's Office and Permanent Secretary, Ministry of Education, has been closely associated with ST from the fledgling days of the defence industries. A Colombo Plan and President's Scholar with a First Class Honours degree in Mechanical Engineering from Adelaide University, he began his exceptional career in public service in the Public Works Department. Shortly after, he joined the Ministry of Defence. In a career marked with many key appointments, he was variously the first GM of ST Auto; the Principal Private Secretary to the Prime Minister; Permanent Secretary, Mindef; and held concurrent appointments as Chairman, CPF Board; Chairman, STH; and Deputy Chairman, ST. Presaging his recent appointment in the Ministry of Education, Lim was one of a team of 12 scholars appointed in 1980 by the then Deputy PM and Minister for Education, Dr Goh Keng Swee, to totally review the Singapore education system. Lim currently retains his links with ST as a Director of Temasek Holdings.

A Federal Express Jet being serviced by MAE in Mobile, Alabama.

The Singapore Model of State-owned Enterprises

The defence manufacturers' legal status as companies was only meaningful to the extent that their owner – the government – was prepared to treat them as such. This could hardly be taken for granted in the 1960s and 1970s, decades before it became universally axiomatic that private enterprise was the best vehicle for production. Singapore, like many countries in the developing world, established state-run enterprises to jump start its economy; but unlike many other countries, Singapore did not run these enterprises on narrowly conceived socialist or state-corporatist lines. By all accounts, the defence companies enjoyed significant autonomy from early on, and their freedom from bureaucratic control only grew with the years.

Mr Lim Siong Guan, involved with the group from the time he was appointed Deputy General Manager of Singapore Automotive Engineering in 1971 (now ST Auto) at the age of 24, said that there was less of an "arm's length" relationship between Mindef and the defence companies in the early years, compared with the 1980s and 1990s. It was not uncommon in the 1970s to find Mindef officers active in the companies' boards, and even in their management. Significantly, however, these officers ran the companies on commercial lines, their main concern being to help them grow and develop, rather than extract maximum short-term benefits for Mindef.

"Mindef recognised that it was in its own interests to have strong defence companies", said Lim, who was Permanent Secretary of the Ministry of Defence before moving on to the Prime Minister's Office and the Ministry of Education. Mindef, he said, knew that the defence industries' ability

A major strategic reason for a local defence industry is that it is part and parcel of operational readiness. A local defence industry can ensure the availability of essential military supplies in the event of hostilities, and augment the deterrence value of an armed force in peacetime.

to contribute to the SAF depended as much on their commercial viability as on their engineering ingenuity. That same recognition prompted Mindef later to support the diversification of the defence industries into non-defence areas, precisely because it made business sense, instead of keeping them bound to a narrow or limited conception of their function.

This kind of entrepreneurially-oriented thinking in Mindef was in line with the government's as a whole with regard to GLCs. The Singapore government was convinced that state-owned businesses should not be run as though these businesses were extensions of the state bureaucracy. Many of Singapore's civil servants did indeed double up as corporate managers – the roll call of such mandarin-managers would include some of modern Singapore's best and brightest: Hon Sui Sen, Howe Yoon Chong, George Bogaars, J Y Pillay, S Dhanabalan, Sim Kee Boon, Philip Yeo. But it was clear that these and other civil servants, when they managed government-owned enterprises, did so, not as bureaucrats, but as managers.

What was at issue, thus, was not the origins of the individuals concerned – whether they were civil servants or not – but their functions: they were civil servants when they were civil servants; and they were allowed to function as entrepreneur-managers when they had to run state enterprises. The structure and mode of operation of government-linked companies allowed them to wear two hats, and equally significant, change hats frequently, without importing into one or the other of their roles, the habits and frames of mind that belonged to the other. It was clear from early on that government-linked companies, even if they were run by civil servants, had to be run on the basis of the profit motive.

"Control and supervision are minimal", Dr Goh said of Singapore's state-owned enterprises. The government is involved in the appointment of the chief executives, and also the boards of directors. But the boards, like those of private-sector enterprises, exercise only nominal authority. "The real control rests with the enterprises' management and as long as the business is profitable, the function of the board is mainly to give formal approval to proposals from management."

In the Singapore model, state-owned enterprises are an important vehicle of entrepreneurship. Managers are held accountable for the performance of their business, and to discharge this responsibility, they are given full authority. "They have the right to hire or fire. Nor are they required to buy from assigned sources of supply or sell to specified buyers", Dr Goh said.

This approach allowed state-owned enterprises to act entrepreneurially. As Dr Goh noted, according to the American economist and sociologist Joseph Schumpeter, the functions of entrepreneurship in modern industrial states are performed, not by business tycoons, but by business corporations. Authority rests with the managers, not owners. This is the case too with Singapore's state-owned enterprises.

Opposite Page
Back in the mid-1980s ST Auto's inspection centre was the only one in Singapore to support the compulsory inspection of heavy vehicles and buses. A decade later, it had two centres, providing inspection services for a full range of vehicles.

Early Attempts at Rationalisation

ST Auto's Infantry Fighting Vehicle is Singapore's first indigenously designed and produced Armoured Personnel Carrier.

As we saw earlier, the slew of defence companies that were established in the 1970s were all formed in the CIS mould, owned by the Finance Ministry, but with Mindef as the supervising ministry. As two academics, Dr Bilveer Singh and Mr Kwa Chong Guan, wrote in a 1989 paper, though the different defence companies grew separately, they eventually became one "big oak tree called the Singapore Defence Industries". Inevitably, the time came for rationalisation. "While the particular needs of the 1960s and the 1970s compelled the growth of individual defence companies, by the late 1970s the existence of more than 16 companies forced the government to undertake a review of the industry. Partly in response to this, a rationalisation programme was launched in 1982, with the aim of allowing for synergies [among the various companies]."

The first step towards rationalisation took place as early as 1974. On January 3 that year, Sheng-Li Holding Pte Ltd was incorporated. The name, 胜利, is the Chinese word for "victory". Sheng-Li's purpose was to provide a monitoring system for companies in which Mindef had interests. Through a share exchange with the Minister for Finance (Incorporated), Sheng-Li became the holding company of the eight companies in which Mindef already had interests. The late Ong Kah Kok became the first Chairman of the Sheng-Li Board.

Among Sheng-Li's objectives were: to monitor the various companies and ensure that they remained profitable and supported Mindef by maintaining strategic capability; to coordinate their activities and avoid duplication; to provide management services; and to coordinate the investment of surpluses. The Finance Ministry got the Development Bank of Singapore, another state-owned enterprise, to provide management services. Kua Hong Pak, seconded from the bank to serve as Managing Director of Sheng-Li, recalled that at its first board meeting on the 25th of January 1974, Dr Goh outlined the directions for Sheng-Li as a sort of watchdog company. Sheng-Li had to initially take on an auditor's role and ensure controls over cost and the proper determination of prices, as well as strengthen the management systems of the various companies.

Kua noted: "Unlike the present ST which has developed a substantial non-Mindef business, in those days, these companies were engaged largely in Mindef-based activities. So monitoring by Mindef was important. The policy directions for corporate governance came directly from Dr Goh. He had a very fertile mind and was preoccupied with how to grow the Mindef companies. Through regular meetings with the managers of the defence companies, he followed intimately the developments of our companies. Many decisions were made at such meetings."

As MD, Kua made regular visits to the subsidiaries. "I met with resistance from management initially, but after a few such visits, and with official letters signed personally by Mindef's Permanent Secretary endorsing my visits, I was able to make headway, and soon after, the managements came round. I made my presence felt by attending their board meetings, and made clear that both Ong and myself were always available to them. Corporate governance was effectively achieved through this open door policy without the need for tough enforcement measures."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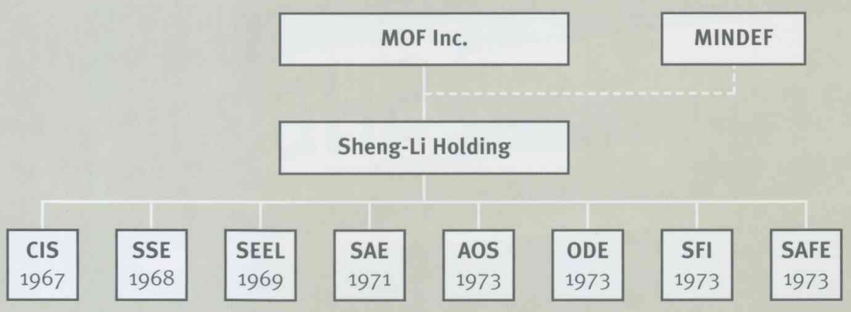
SAE

Sheng-Li Holding (1974)



The structure of Sheng-Li Holding when it was formed in 1974.

Sheng-Li Holding (1983 to 1989)

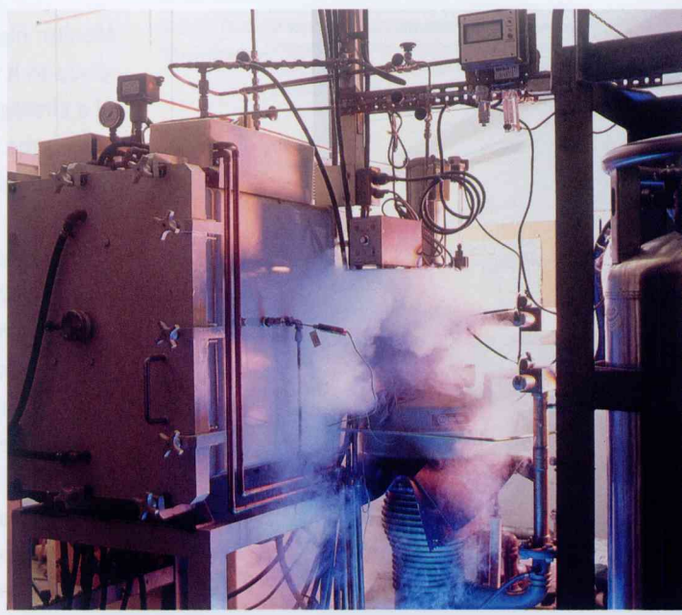
STC (Singapore Technology Corporation) was formed in 1983 to consolidate Sheng-Li's ordnance activities.

Ms Chua Su Li, ST's Company Secretary, also recalled the easy informality of the early days: "A close working relationship existed between Sheng-Li and key Mindef officers who had frequent dealings with the defence companies. In part, this was due to the keen personal interest Dr Goh took in the progress of the defence companies. The co-operative relationship was also due in no small part to the personality of the late Ong Kah Kok."

Every Saturday morning, Chua recalled, senior Mindef officers and some of the CEOs of the defence companies would gather together in Ong's room for breakfast. "I could hear their peals of laughter. They were obviously having a good time, and in the process, sharing information and getting things done in the spirit of cooperation that Ong was very good at fostering."

Future Cabinet Minister, Mr S Dhanabalan, then at DBS, was also on the Board of Sheng-Li. Sheng-Li's staff, Kua noted, was always below ten.

In 1979, Cheong Quee Wah, then concurrently Permanent Secretary of Mindef, became Chairman of Sheng-Li. Towards the end of 1980, Howe Yoon Chong, then Minister for Defence, commissioned Mr J J Gerzon (former CEO of Shell) to review the Sheng-Li group of companies. The Gerzon Report urged the merging of companies which engaged in similar activities. In 1981, the group was reorganised into Ordnance, Aerospace, Marine and General Services arms. The aerospace activities were consolidated under Singapore Aircraft Industries (now ST Aero) in December of that year. In 1983, Singapore Technology Corporation was formed as the umbrella for Sheng-Li's ordnance companies. Philip Yeo, then Chairman of CIS, modelled STC after the Israeli Military Industries (IMI) and other ordnance conglomerates worldwide. The fourth area, services, included Singapore Food Industries and SAF Enterprises.



A sintering furnace in operation at Advanced Materials Technologies. 'Sintering' is the process of heating powdered material into a solid. AMT manufactures precision components through metal injection moulding, debinding and sintering processes.

Singapore Test Services provides specialised test and inspection services for CIS and other companies in the region. STS does calibration and measurement; environmental reliability testing; chemical analysis; explosive, propellant and pyrotechnics analyses; precious metal assaying and hallmarking; and precision selective electroplating.

Monitor and the Birth of ST

In 1987, shortly after Lim Ming Seong took over as Group Managing Director, Sheng-Li formally adopted a Charter, endorsed by Mindef, which spelt out, among other things, that the defence industries would undertake industrial and commercial activities that had synergies with, or supported and extended, the core defence-related activities.

At the same time, Sheng-Li embarked on a major exercise in self-analysis, later to become known as the Monitor Study. The Study was led by Professor Michael Porter, a notable scholar from Harvard University's School of Business. The Monitor Study, presented to the Executive Committee of Sheng-Li in August 1988, paved the way for a unifying corporate identity to emerge – Singapore Technologies.

Monitor highlighted several strategic weaknesses in the group as it then existed. In particular, it noted an absence of a strategic management process; a lack of synergy among the entities in the group; and a lack of information dissemination within the group.

The weaknesses were deemed so serious that the study recommended that diversification plans be postponed if the problems were not addressed. Monitor recommended that the group divest or exit from some of the commercial businesses, and perhaps some military export ones as well, and realign and consolidate the remaining companies.

Monitor maintained that military and commercial ventures could not co-exist successfully within the same companies. When defence companies diversified, there tended to be fragmentation and lack of focus, and a dilution of leadership, Monitor believed.

Monitor also found that business development units at the group level had been ineffective, as it was a staff group decoupled from control over assets and key resources. A new organisational structure was thus needed.

Concurrent with the Monitor Study, the group embarked on a major exercise to define a single strong corporate identity. This was deemed important for diversification, especially internationally. For this purpose, the group engaged Landor Associates to work with the management. The result was the name "Singapore Technologies" and its distinctive sunburst logo. ST was envisioned as "a quality technology-based engineering and services group headquartered in Singapore", differentiated from its competitors in terms of "resourcefulness, reliability, responsiveness and relationship".

The first company in the group to use explicitly the new name was Singapore Technologies Industrial Corporation (STIC) in April 1989. STIC was established in response to Monitor's recommendation that non-defence businesses be hived off from the defence core.

The divorce was by no means total: shipbuilding and aerospace companies, for example, continued to serve military and civilian markets on parallel tracks. ST was not convinced of the need for a clean separation between the two.

As *Making the Future*, a 1993 ST internal report, noted, "Monitor's recommendation meant a separation by customer and market". The group decided that the more sound approach was to seek growth "leveraging on core competencies and capabilities irrespective of whether the end products and services [were] defence or non-defence".

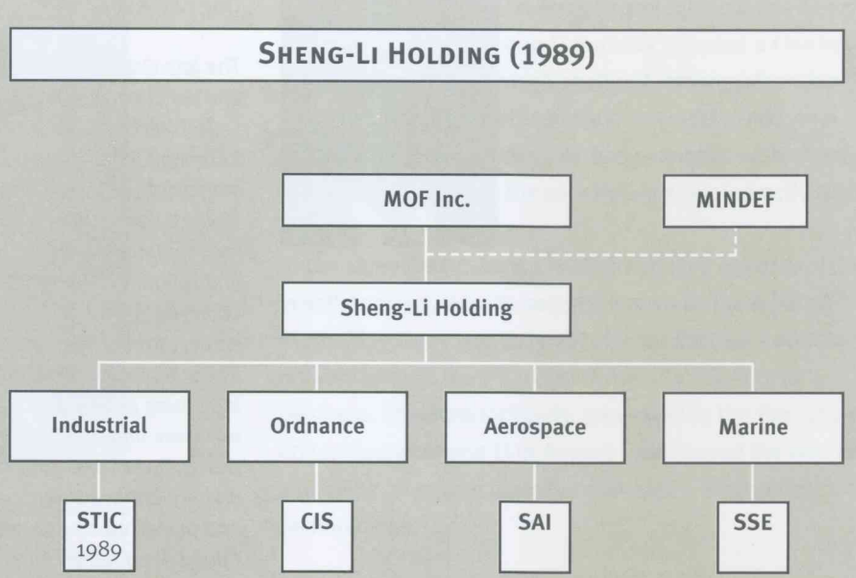
This insight was to prove prescient. As has become clear in recent years, military technology cannot be divorced from commercial technology. Especially because of advances in systems engineering and computer science, technology today flows as much, if not more, from commercial products to military products, as the other way round. For example, the US government's formation in 1987 of a joint industry-government consortium in semiconductors, Sematech, to help the US regain leadership in the field, was prompted by both commercial and military considerations, and it was not possible to tell which consideration was more important.

In May 1990, Sheng-Li Holding was officially renamed Singapore Technologies Holdings. The main arms of the group would soon bear the ST family name and several of its key companies would use the sunburst logo. The name and logo would allow different parts of the group to go out into the world and promote themselves on the basis of the strength of the whole.

Ong Kah Kok

The late Ong was Chairman of Sheng-Li and concurrently Chairman of CIS and ExCo Director of ST Shipbuilding in the latter half of the 1970s. Known to his staff fondly as 'OKK', he is remembered by his colleagues as a boss who was magnanimous of heart. He could be firm and tough, yet kind to those who needed his help, and commanded much respect from those who dealt with him. Philip Yeo paid tribute to him for grooming young people and giving them exposure and opportunity. In Yeo's words, "when the gods threw thunder and lightning, he deftly deflected them and protected his subordinates." Lai Chun Loong remembered Ong as the tough but benevolent boss who "brought us up".

The "Tai Ping", a 282-passenger high speed catamaran ferry built by ST Shipbuilding. The vessel is owned by Dong Guan City Humen Hong Kong/Macau Passenger Ferry Co.



In 1989, STIC was formed to group all of Sheng-Li's non-defence businesses.

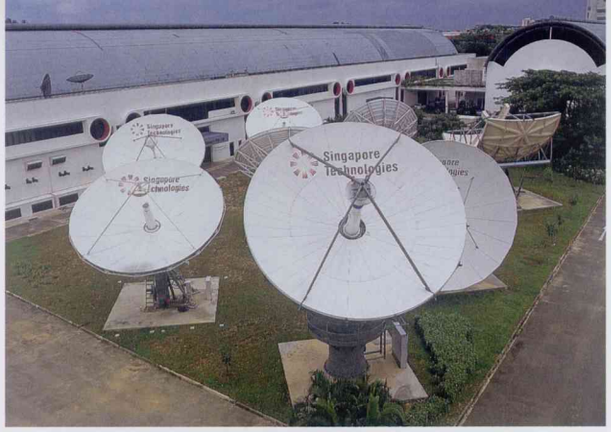
LISTINGS

The mid-1980s marked a turning point in the Singapore economy, with major long-term implications for all of its state-owned enterprises. In 1985, the economy went into recession for the first time since independence. On hindsight, and when compared with the prolonged stagflation that other countries suffered, Singapore's two quarters of contraction seems slight.

The recession, however, provoked a wide scrutiny and examination of the structure of Singapore's economy. An Economic Committee, comprising representatives from both the public and private sectors, was set up by the government for this purpose, with several sub-committees examining different sectors. Inevitably, questions were asked about the role of state-owned enterprises.

The sub-committee on entrepreneurship, for instance, concluded that while state enterprises had been necessary for Singapore to attain its status as a newly industrialising country, these enterprises, "in fulfillment of their aspirations for corporate growth, adaptation and long-term self-sustainability", had evolved beyond their initial charters. In doing so, they had become a major source of concern among local private-sector businessmen, the report said.

Much of this criticism was in the end determined to be more the result of perceptions than of reality. After all, the commercial principles which governed the operations of government-linked companies and statutory boards, meant that the worst stereotypes of state-owned enterprises worldwide – bloated, inefficient and loss-making – never applied to the Singapore species.



ST Teleport's facilities at Ayer Rajah offer state-of-the-art C-band uplink/downlink to several satellites.

Nevertheless, the concerns of private-sector critics, plus the attractiveness of the private-enterprise model of doing business, became catalysts for the privatisation in its various forms of state-owned enterprises. Accordingly, in 1987, the government's Public Sector Divestment Committee urged that the private sector be used as the engine of economic growth.

In crucial respects, the privatisation of GLCs was a fulfillment of the very principle upon which they were founded: namely, that they be run on commercial principles. Stock market regulations, for example, which required periodic public disclosure of financial results, did not come as a surprise to the management of GLCs because they had always been made accountable for the performance of their companies without the aid of public subsidies or safety nets. Unlike the privatisation of failing nationalised industries in other countries, in Singapore's case the private sector was not called upon to come to the rescue of the public sector, but rather, to augment qualities that were already present in the public sector.

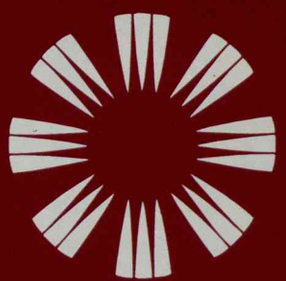
The GLCs, thus, saw the movement towards listing as a natural progression. Indeed, the entire public sector was touched by this thinking, including the defence industries. A paper approved by Mindef in 1989 noted that listing would allow the government-owned vehicles to raise finance and to effect share-swap arrangements in joint-ventures or takeovers. "This is crucial when ST's defence and core industrial companies grow through strategic partnership and alliance with other publicly-listed foreign technology-oriented corporations", the paper argued.

Going public would also provide a real "market test" of the efficiency of the ST companies. "For the ST group to play its role of a Singapore MNC, it is crucial that it shed its present image of a wholly government-owned group. The best and fastest mechanism to shed this image is to go public."

Less than a year after Mindef gave its green light, the public was able to get its first bite ever of stock in a Singapore Technologies company. ST Aero and ST Shipbuilding were both listed in August 1990. A year later, a string of other listings followed: ST Capital and ST E&E in August 1991, ST Auto in September, and ST Computer Systems & Services in November.

In its core defence companies, ST maintained management control after listing by retaining at least 51 percent of the shares. Individuals could not hold more than five percent of the stock, and foreign ownership was initially limited to 15-25 percent, but discretion was given to the listed companies in 1997 to raise these limits to 49 percent whenever it was felt appropriate. In addition, a special share ensured that the government, through the Minister for Finance (Incorporated), would have the right of veto over certain matters, including capital reduction, divestment of subsidiaries, and the appointment and removal of directors. There were some exceptions to the above conditions. For example, upon listing, ST Capital did not have a foreign ownership limit imposed on it, and when approval was given for CSM to list, there were no requirements for any special controls like foreign ownership and individual shareholder limits.

Sunburst: A Multinational Consolidates its Identity



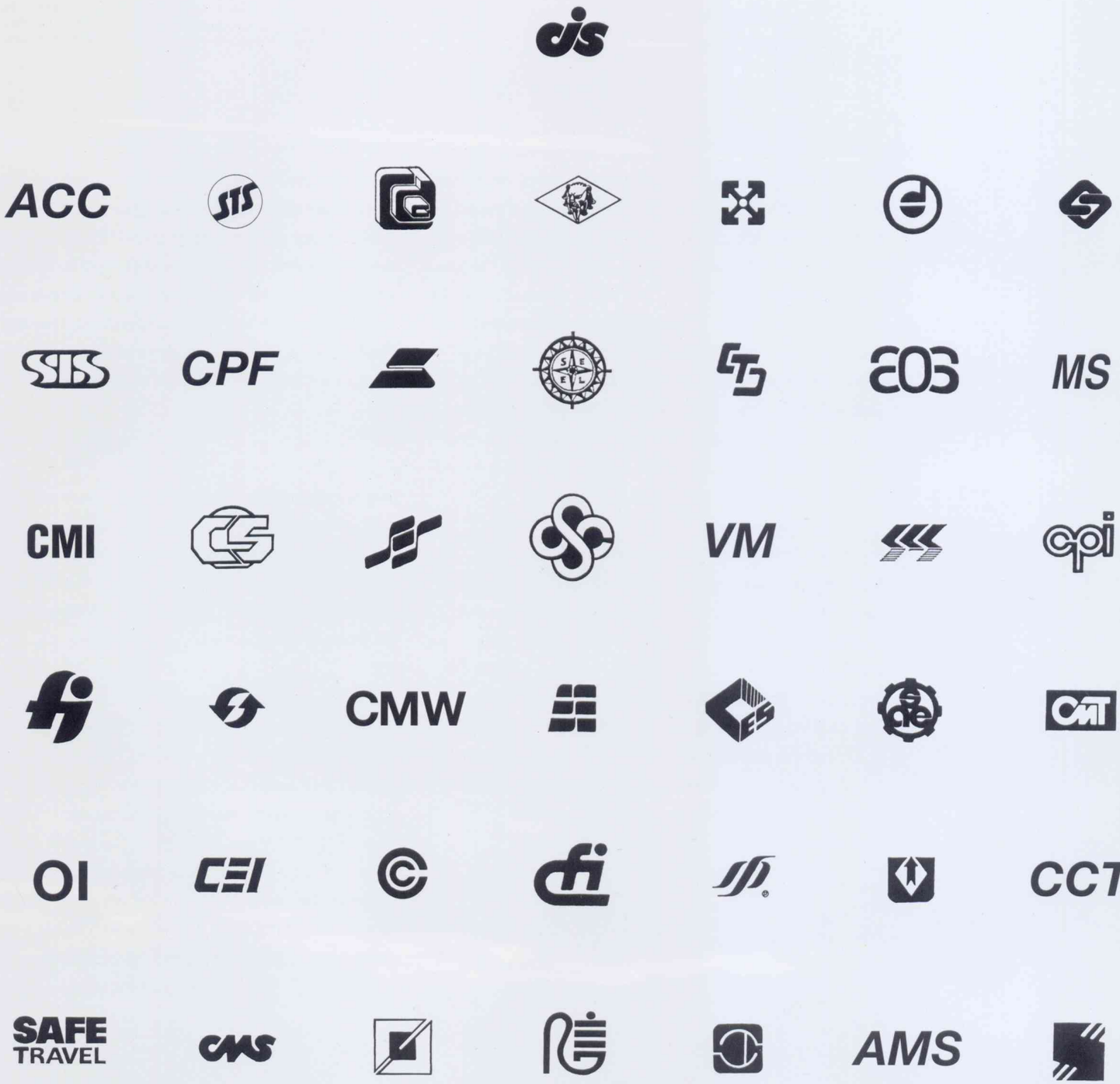
Singapore Technologies – the name makes perfect sense today, for how else would one name a Singapore-based multinational conglomerate that is in aerospace and ammunition, semiconductors and shipbuilding, telemedia and tank-retrofitting, plus a host of other high-tech businesses? But even as late as the mid-1980s, when the defence industries were well into commercialisation and diversification, the group had yet to develop the right formula for its corporate identity. Over the years, as the companies within the group reorganised, changed names and logos, and undertook an ever expanding assortment of activities, the identity of the group as a whole ran the risk of becoming diffused .

The name 'Singapore Technologies' first emerged in 1983 when Singapore Technology Corporation (STC) was established to consolidate all of Sheng-Li's ordnance activities. Then in 1989, in response to the Monitor Study commissioned by Sheng-Li, Singapore Technologies Industrial Corporation (STIC) was established. Monitor had suggested that the military and commercial business units be separated, and that the latter be substantially reorganised. The result was STIC, which consolidated the non-defence businesses. It was the first company in the group since STC to take on the appellation 'Singapore Technologies'.

Concurrently with the Monitor Study, Sheng-Li engaged Landor Associates, an international design and identity consulting firm, to define a strong and unified corporate identity for the group. As a result, on the 11th of May 1990, Sheng-Li Holding was renamed Singapore Technologies Holdings, thus inaugurating the ST era. Under the new corporate identity, most business units in the group carried the ST family name and used the new sunburst logo (exceptions to the name change were companies like CIS and CSM). Symbolically, as well as materially, the group became one.

The new identity was an essential prerequisite for the next stage of ST's expansion – an expansion not only in the scale and scope of its activities, but also geographically into the region and the world. With a clear corporate identity unifying all the companies in the group, ST acquired a more noticeable presence both domestically as well as regionally. Every arm of ST could now compete and grow by drawing on the combined strength of the group, rather than as separate and discrete units. The whole became greater than its parts.

ST's logo, the sunburst, symbolises the strength, energy and brilliance of the sun. The individual elements of the symbol combine to create a whole – Singapore Technologies. The eight elements suggest the points of a compass, signifying ST's outward movement into international markets. The symbol conveys a sense of order and precision even as it suggests the promise of adventure and discovery that has always been associated with a burst of sunlight.


ACC
CPF
MS
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SAFE
TRAVEL
AMS

Opposite Page
45m Missile Attack Craft on manoeuvre. Nations, as Charles de Gaulle was fond of saying, do not have permanent allies or enemies, they only have permanent interests. Even among friendly nations, interests do not always coincide. By giving the country some degree of self-sufficiency in military supplies, the local defence industries make Singapore less dependent on the major powers, who are also the major arms suppliers.

To prepare STIC for listing, start-up companies were taken out of its portfolio in September 1990, and re-grouped in Singapore Technologies Ventures. On the 15th of June 1993, after three straight years of profit, as required by the Stock Exchange of Singapore, STIC was listed and traded on the main board. It offered 170,667,000 ordinary shares to the public at a fixed price of $0.85 per share and $1.20 per share by tender. The issue was oversubscribed by an average of six times. In 1994, the public held 25 percent of STIC's equity. In 1996, STIC was listed on the Morgan Stanley global index, as a stock whose health was indicative of the health of global stock markets.

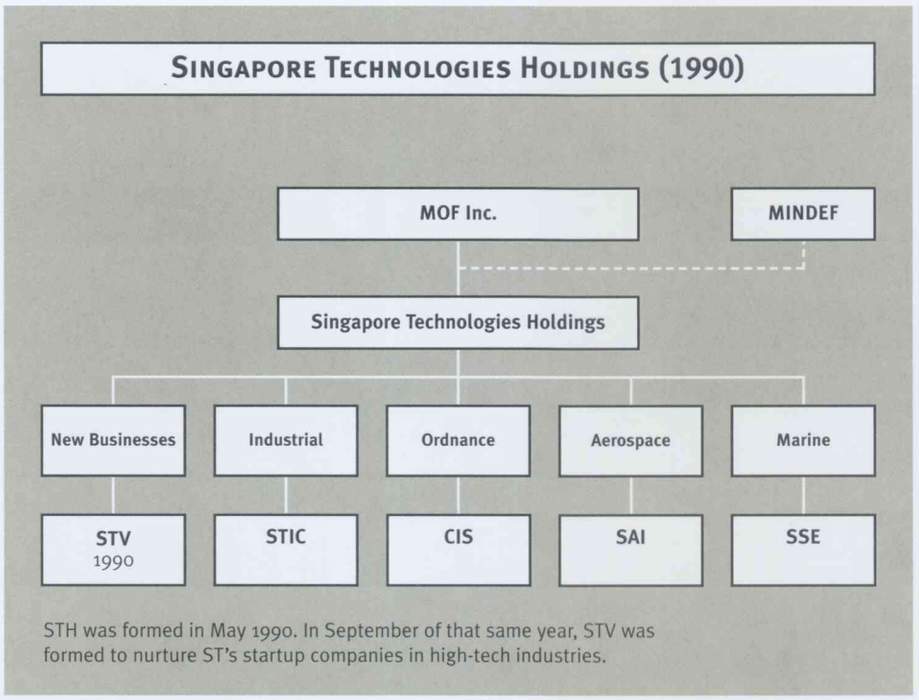
But public listing was "not an unmitigated blessing", as *Making the Future* noted in 1993. Listing "cannot free the companies to act and take risks as they wish because government remains politically accountable so long as the company remains a GLC". The report added: "Public listing reduces the flexibility of ST in such matters as the mobilisation of financial and human resources groupwide in ST, and the ability freely to direct restructuring and realignment of businesses within ST, although it has been a welcome source of additional funds."

For Philip Yeo, being at the mercy of stock markets was sometimes no better than having to answer to bureaucrats. This was one reason why he put off listing STIC while it was knee-deep in Batam. "I didn't want to touch it. See, when you're doing development work, long-term work, people in the market do not understand, they are very fearful. There is an advantage in keeping the development entities unlisted, then you can take a long-term view."

Not surprisingly for a group with a culture of constant self-evaluation, the listing of STIC also touched off an internal debate about the larger purpose of the group. One of the people who needed convincing about the group's direction was top civil servant, Mr J Y Pillay, Chairman of ST's board from December 1991 to June 1994.

Pillay, an engineer by training, joined the Finance Ministry in 1961, and rose to become the top-ranking officer of the elite Administrative Service when he retired in 1995. He was also Chairman of the Development Bank of Singapore (1979-85), and the Managing Director of the Monetary Authority of Singapore and the Government of Singapore Investment Corporation (1985-89). In the public's mind, however, his most prominent appointment was that of Chairman of Singapore Airlines, which he led from its inception in 1972 to 1996, and transformed into the most consistently profitable airline in the world.


P 80



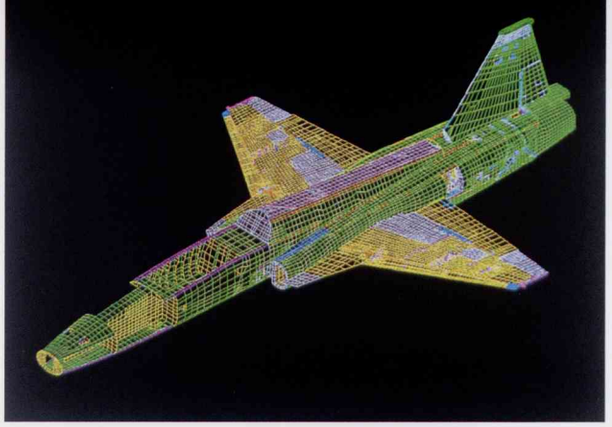
STH was formed in May 1990. In September of that same year, STV was formed to nurture ST's startup companies in high-tech industries.

In the top-most echelons of Singapore's Civil Service, Pillay was the quintessential manager-bureaucrat. He provided and demanded, above all, focus and logic in his enterprises. He was unimpressed with sales growth as such, measuring companies by their rate of return instead.

Singapore Airlines reflected Pillay's approach. Even while other large corporations in Singapore were ploughing their profits into local and regional property markets, SIA stuck scrupulously to the airline business. In an interview with the *Business Times*, Pillay quoted the *Bhagavad-Gita*, the 2,600-year-old Hindu text: "Many-branched and endless are the ways of the man who lacks determination, who lacks will." He said his main advice to staff and colleagues was always: "Look, whenever you embark on anything, please tell me what is your object. And there must be one. I don't want five.... I don't want the principal object to be fudged."

Coming from the institutions he did, it was not surprising that Pillay felt that the ST group had gone beyond its fundamental, original purpose, which was to support defence. Its *raison d'être*, he felt, was being diluted by branching out into non-defence areas. On the other hand, Philip Yeo, who was ST's Exco Chairman while Pillay was ST's Board Chairman, felt that unless the group diversified into commercial areas, the defence-related components themselves would fail.

The differences in philosophy between these two formidable individuals, Yeo and Pillay, reveal that Singapore's bureaucrats are not, as myth would have it, faceless and



CAD/CAM at work in the Engineering and Development Centre of ST Aero.

interchangeable. The smooth surface of Singapore's GLCs belie the sharp debates over strategy which go on behind the scenes. Some of the energy that GLCs display derives precisely from the fact that such debates take place – frequently.

In essence, the internal debate was about direction and strategy. Was ST to remain a solely defence-related conglomerate or was it to become a broad-based technological corporation? Should it remain wedded to particular businesses or should it leverage its skills to move into new areas?

Characteristically, ST decided that the proper answer to such questions was *both*. In the US, there is General Electric, a broad-based operation, as well as Microsoft, an entity focused on one thing. The models serve different, even incompatible purposes: a GE cannot do what a Microsoft does, and a Microsoft cannot do what a GE does. The choice of models, in other words, is a function of purpose. Given ST's aim – to become a broad-based technological corporation – it could not have adopted a model more suited to an entity devoted entirely to providing a particular service. ST was to soon resolve itself into five main competencies, in each of which its companies were to dig deep, while the group benefited from the synergies of the whole.

Cheng Fook Choon

The late Cheng Fook Choon is credited with the setting up of Ordnance Development & Engineering (ODE). Under his leadership, ODE established itself as the foundation of ST's ordnance engineering expertise. In 1982, Cheng left ODE to set up Singapore Aerospace Manufacturing. A graduate from the University of Singapore with an Honours degree in Chemistry, Cheng joined CIS in 1971. He spent his entire working life with the ST group, and was well respected for his integrity and missionary zeal, and above all, his dedication and commitment. In honour of his memory, "The Cheng Fook Choon Award for Process Improvement" was established in 1992 to encourage and reward work teams and groups which strive for process improvement in the ST group.

Loh Chuk Yam

Loh is currently President of Singapore Technologies Precision Engineering as well as of CIS, and is Group Director of ST. After two-and-a-half years at Mindef, he joined the ST group in 1975. He has attended Harvard Business School's Advanced Management Programme and holds an Honours degree in Mechanical Engineering from the University of Singapore.

Loh recalled his early days at ODE: "Solving production and engineering problems was the major concern. We were taking on all kinds of projects and inevitably quality suffered and delivery schedules were way off target. So we had to refocus on our bread and butter projects, and do them well. Also, I realised the key to success rested with the staff. At the time, the attrition rate was high and our people lacked experience. But today ODE has a team of experienced and dedicated engineers and technicians."

The landmark Monitor study may not have convinced the group that it was necessary to split non-defence from defence businesses completely, but ST was sold on the study's recommendation that it had to restructure its 'strategic architecture'.

This effort was given a boost when Lim Siong Guan, who had been a director of STH since 1981, became Chairman of its Executive Committee in August 1992. Insiders recall that Lim's major contribution to ST was his clarity of thought. He believed in the need for proper organisational frameworks and systems as a means of fully realising the energies and talents of people.

In the early 1990s, putting in place such systems was a challenge at the group level. The defence companies had grown diverse and apart. In some cases, subsidiaries were competing with each other on the same ground. When overseas, they were knocking on doors as separate small companies, rather than leveraging on the expertise and name of a single large group.

Lim set in motion a series of study teams, and got managers involved in thinking about the positioning of the group and where they wanted it to be in the future. "Really, a lot of it involved a self-recognition of the strengths and weaknesses of the group", he said. The process of clarifying and coming to grips with ST's problems was perhaps as important as the internal report, *Making the Future*, that was the eventual product of the process.

The Singapore Mint, a subsidiary of Singapore Technologies Precision Engineering, has produced and marketed coins, medallions, ingots and other precious metal products for more than 16 countries.

The report, coming five years after the Monitor Study, stated: "The success of ST in the long run will be enhanced or circumscribed by the extent and quality of its strategic management. The quality of thinking at senior management levels is crucial to success. Their vision of where the organisation should go and how it is to get there decides its fate.

"Perhaps the most challenging task is cultivating a culture and value system appropriate to the vision. This involves questions of organisation, organisational development, motivation, compensation schemes, people selection, and internal power politics."

With such goals very much in mind, the group was restructured again in February 1995. Companies were grouped under 14 Strategic Business Areas (SBAs) – Ordnance, Automotive, Aerospace, Finance, and so on.

The former Singapore Technologies Ventures (STV) was restructured and renamed Singapore Technologies Pte Ltd, and became the operational headquarters (OHQ) of the group. Its role included: studying future businesses; managing senior executive staff; monitoring the financial discipline of the SBAs; inculcating a single set of values; and promoting a unified corporate image.

The restructuring created a two-tiered board: the Singapore Technologies Holdings (STH) Board, chaired by the Permanent Secretary of the Ministry of Defence, Mr Eddie Teo, and the Singapore Technologies Pte Ltd (STPL) Board, with Dr Yeo Ning Hong, the former Defence Minister, as its first Chairman. The STPL Board consisted primarily of directors with a bent towards international business, in preparation for STPL being listed sometime in the future.

In April 1997, Dr Yeo stepped down, and was succeeded by Mr Teo Ming Kian, Permanent Secretary of the Ministry of Communications, who became non-executive Chairman of STPL.

With the restructuring, the key leadership role at OHQ was assumed by Ho Ching. Earlier, as head of Singapore Technologies Ventures (STV), she had seen through the successful turn-around of the semiconductor business – despite, and in the teeth of, considerable scepticism and opposition, as we have seen. She has been intimately involved with the group since 1987 when she joined the group as Director of Engineering at Singapore Technology Corporation.

Singapore Technology Corporation was at that time the umbrella for the ordnance and automotive companies of the group. The automotive arm was then little more than a 'panel beater', knocking out dents in general purpose cars or refurbishing tanks and armoured personnel carriers. "So one of the things that we did at the corporate engineering level", Ho Ching recalled, "was to start what we called a 'technology demonstration programme'. It was basically an experimental programme where we put together a concept for an experimental platform for armoured vehicles."

An ST Auto worker servicing the engine of the M113 Armoured Personnel Carrier.

Previous Spread
C-130 tanker conversion.

Pidemco Land, a new member of ST, is one of the largest developers in Singapore's property market and has in its stable such popular commercial complexes as Funan Centre and Orchard Point, and recently, executive condominiums such as Westmere and Eastvale. Its residential projects in 1997 included Hillbrooks and Seasons Park, both among the top-ten selling projects for that year. Pidemco Land is also active overseas. In 1997 it had projects in China, Myanmar, Vietnam, Malaysia and the United Kingdom.

The automotive arm at the time was losing money and had neither the people nor the finances to support such work. "So CIS corporate engineering funded us", Ho Ching said. The programme built up a team able to focus on the company's core capabilities and keep looking ahead to the next-generation armoured platform carrier. "So you try out things like active suspension, you try out things like modern electronics, automatic transmission, and so on."

The programme also allowed the company to go directly to users and show, rather than just tell, what new products were in the offing. "I mean, you tell them some technical terms, they won't appreciate what you're talking about. But if you build a prototype and say to them, 'hey, I'm trying this out, it's active suspension, please go drive and feel it for yourself,' that's different."

"In that way we built a bridge to the users. And today, you see in ST Auto a very strong core of engineering capability. They've got good engineering skills, able to work with users very closely, and to conceptualise not just what you need today but what you might need ten years from now."

If this experience was a pleasant example of what could be achieved at the group level, her time at Singapore Technologies Ventures provided a taste of the more painful side of corporate decision-making. STV grouped together new ventures, many of them unprofitable initially. "We established STV with a clear expectation that we needed to do something about these companies. If we could not do something positive, then we closed them down and wrote them off."

In 1997, Ho Ching, by now President and CEO of STPL, saw her primary role as developing and putting in place strategic management systems that would allow ST to grow in a disciplined way without smothering the independence of its member–companies. A creative "what-next" mentality had allowed ST to grow, she noted, but "what-next means, you have a company, what do you want to do with it? What shape do you want it to take ten years, 15 years, 30 years from now? It does not mean: 'what is the next new toy?'"

ST would focus on the five areas of technology, engineering, infrastructure, property and finance, she said. When entering new businesses, ST would consider the following:

- Whether there was a large enough market potential for ST to grow into a significant player in that business, internationally or regionally;

- Whether ST can add value to be competitive and grow into the number one, two or three in the market.

"If we want to make a major move into something, these are the conditions which we feel must obtain, otherwise it makes no sense for us to put in resources and expend energies." The group would also have to take a hard look at existing companies, and assess their long-term capability. "What is the strength that we must focus on? We can outsource everything else. We can outsource manufacturing. There's nothing to say that the 155mm gun must be produced in Singapore. Can I produce it somewhere else?"

Singapore CableVision offers over 30 channels of information, entertainment and multicultural programming, and aims to hook up public residential towns and private housing nationwide.

At the group level, ST has diversity and thus breadth. But individual companies have to 'drill deep' to be very good. The semiconductor group was a good model, Ho Ching noted: "We have one company doing wafer manufacturing, one company doing test and assembly, one company doing chip design. Each will concentrate on just that one thing and make sure that it drills very, very deep and be the best in that particular field.

"In the infrastructural group we have a bit of that. Logistics concentrates on nothing but logistics; the people who do industrial parks understand industrial parks inside out; and the construction companies do nothing but construction. So we have this very clear skill differentiations." In the coming few years, she said, the engineering companies would be similarly reshaped.

Ang Swee Kee

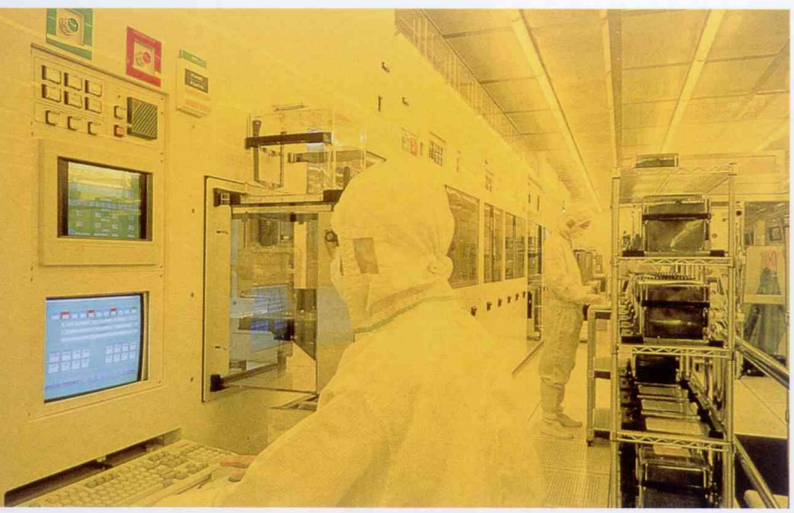
Ang is currently Senior Vice President, Property Management, Pidemco Land, which was transferred to ST in 1996 to become part of ST Properties. Ang worked with the Urban Redevelopment Authority (URA) as a civil/structural engineer and administrative officer before joining Pidemco in 1989. He has a Bachelor's degree in Civil Engineering from the University of Singapore, and an MSc (Transport) from Imperial College, London, which he attended on a URA Scholarship.

The frequent return of satisfied customers such as JAL attests to SASCO's and MAE's quality service.

Opposite Page
The SAFRA Resort Country Club, built by STIC's construction arm.

Sew Chee Jhuen

Sew graduated with a Bachelor's degree in Aeronautical Engineering & Mechanics from the University of Minnesota in 1987, with the help of an ST Undergraduate Scholarship. He then joined ST Aero as an engineer in the Engineering & Development Centre, and was promoted to senior engineer in 1990. In 1992, Sew received an ST Postgraduate Scholarship and went to Stanford University to pursue his MBA. Upon completion, he spent a year at MAE in Alabama, USA. In 1995, Sew returned to Singapore, and he is currently Director (Business Development) Commercial Business Group, ST Aero, and concurrently GM of ST Aviation Resources.



Wafer fabs can run at full steam, 24 hours a day, seven days a week.

Such supervision and intervention by OHQ would have to be carried out without killing one of the group's main strengths: the entrepreneurial spirit of many of its companies. This, after all, was what attracted individuals like Wong Kok Siew and Ho Ching herself to the group. "Our people are fiercely independent", noted Ho Ching. "The challenge is how to combine that will to try and be independent, and to create something better, with an underlying support system that makes sure that even as we grow, we don't get wild outcomes."

Lim Ming Seong, also at OHQ, shared in the challenge. "A large part of my job today is managing these business 'boundaries', so to speak. How do you tell people not to expand beyond their own boundaries? The trick at the end of the day is balance. How do you balance working within a big organisation where you tap the resources of the group, the synergy, with operating at company level, where you are nimble-footed, you are resourceful, you have the freedom to act and move fast? Achieving that balance is difficult. In fact, that is where our greatest problems lie."

ST would not necessarily change its character as a large collection of small companies, Ho Ching said. "I'm not sure if individual companies running around is a bad thing. Proctor & Gamble grew very large that way. The challenge is to combine autonomy with coordination, freedom with discipline."

Discussing problem solving and decision making strategies at Chartered Chemical Industries.

Pamela Chua

Chua has been with the ST Group since the early days, having joined CIS in 1969. Executive Secretary of CSM since 1996, Chua has supported many managers at various business units in her career with the group. For her, this opportunity to do different things has kept work in ST interesting. Reflecting on the beginnings of the company, Chua said, "We worked really hard in the old days; back then we were a small group and were closely-knit".

Koh Beng Hock

Koh's long history with ST began at the very beginning. He started with CIS in 1966 as it was getting off the ground, and in 1967 worked as an apprentice in its toolroom. Soon after, he was sent to Colt Industries (US) for six months training and returned to work at the rifle plant for two-and-a-half years before moving back to the toolroom. In 1984 he shifted to Chartered Metal Industries (CMI) where he was involved in making document handling systems, but returned to the CIS toolroom again in 1989. Koh joined Advanced Materials Technologies in 1994, bringing with him his wealth of experience in precision manufacturing, and he is now Senior Manager, Manufacturing. Koh said, "The important thing is not what you know, but what you do with what you know."

任重而道远
士不可不弘毅

We must do the best we can
The load is heavy and the road is long

Human Resources

The critical factor in achieving the right balance between autonomy and coordination is people. Only by giving subsidiaries enough autonomy could the group attract and retain top managerial and engineering talent. But, equally, OHQ would have to play a major role in the development of human resources if the group is to have any chance of achieving its ambition to be a full-fledged multinational corporation. ST will have to become a cosmopolitan group, employing the best people from throughout the world at every level. As of 1997, CSM alone had people from 22 different countries working for it.

To help build and manage such a diverse workforce profile, ST set up a human resources division at OHQ, headed by Mr Yap Eu Win. Yap's challenge was how to sell the idea of HR management to a very varied stable of companies, from start-ups to mature businesses. "Our HR system must satisfy corporate objectives, and yet be sufficiently flexible to meet the requirements of individual business units", he said. The first ST Human Resource Conference in August 1996 concluded, among other things, that the group had to put in place a 'pro-active' HR system. To this end, ST adopted a number of programmes and schemes.

On the productivity front, the group adopted the Economic Value Added (EVA) management concept and practice to measure the asset productivity of its various units. EVA gave staff a tool to analyse shortcomings and problems in their units, and empowered them to make decisions in their areas of work. Also, the group launched a programme called QUEST – Quality and Excellence in ST – to inculcate a consciousness of productivity among workers and management, and to encourage the participation of all in making operational decisions and suggestions. To date, 1300 QUEST teams or quality circles have been formed, and almost 80 percent of ST's staff have made at least one suggestion. As a result of suggestions from two QUEST teams in wafer processing at CSM, for example, the company stood to reap potential annual savings of more than $5 million. ST's QUEST teams have routinely won national awards for productivity, including ten Gold Awards in 1996 from the Productivity and Standards Board.

On the training front, the group established the ST College in 1995. The College, which consisted of seven full-time staff, offered management courses for the 5,000 or so executives in the group, and organised three-day orientation courses for new recruits. Through the College, as well as the in-house newsletter, *Sunburst*, ST propagated its core values: Integrity, Value Creation, Courage, Commitment and Compassion.

Because ST knows from its own past the crucial role that talent played in its success, it has invested heavily in education. In 1996 alone, it awarded eight overseas undergraduate and postgraduate scholarships in engineering and non-engineering subjects; and to date, it has awarded a total of 426 such scholarships. This is a record that few companies in the world, let alone Singapore, can equal.

But talent must not only be educated but also nurtured. ST therefore established an Executive Resource Unit (ERU), one of the most important units in the HR division. Headed by Ms Cheo Hock Kuan, the ERU identifies talented

While ST may be an incredibly diverse conglomerate, its people and values bind the group together as a cohesive whole.

individuals in the group, nurtures them, and manages their careers on either professional or management ladders.

The ideal workforce profile that ST is shooting for is knowledge-based, high-tech, high-skilled, and high value-added. From the technician on the factory floor to the company president in the executive suite, ST wants people with initiative and commitment, people who possess an innate dignity and self-respect.

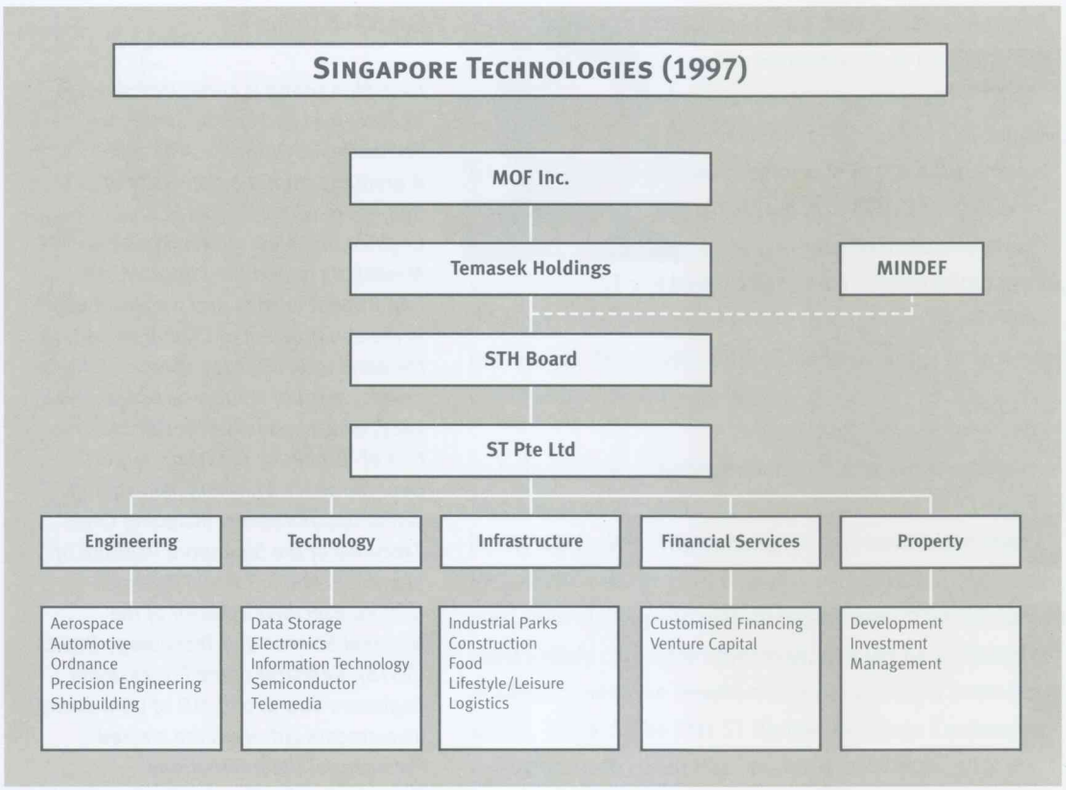
ST's commitment to human resources, however, goes beyond just the bottom line. ST's Recreation Club organises recreational activities for staff, including games and foreign travel. Also, recognising that the health of the corporation is inextricably linked to the health of the community, the group has embarked on a wide range of community services. For example, various companies in the group have adopted homes and participated in charity drives.

One notable instance of ST's community service is the Singapore Technologies Endowment Programme (STEP), launched in 1997 to commemorate the 30th Anniversary of ST's founding. A percentage of ST's annual group profits will henceforth be donated to the fund, and the investment income of the fund will be used for various community development projects – for example, a Youth Camp for upper secondary boys and girls in Singapore and other Asian countries to meet and interact with one another.

Liew Mun Leong

Liew Mun Leong is currently President of Pidemco Land and of Singapore Technologies Properties Pte Ltd. A graduate from the University of Singapore with a degree in Civil Engineering, Liew started his career in Mindef. He joined the Public Works Department in 1975 and was involved in the construction of Changi Airport. In the early 1980s he took charge of the development of military airbases, and in 1985, was responsible for the construction of Terminal 2 of Changi Airport. Over the years, Liew has held various senior appointments, including Chief Executive of the Singapore Institute of Standards and Industrial Research (SISIR), Executive Director of the National Science and Technology Board (NSTB), Registrar of the Professional Engineers Board, and MD of L&M Group Investments Ltd. He is the elected President of the International Organisation for Standardisation (ISO) for the 1997 to '98 term.

ST Family Day, 1996.



Speaking to the group's executives in April 1996, Ho Ching commented on the group's diversity: "from baking *kueh lapis* to baking semiconductor wafers, from guns to hotels, from sea to air, from submicron resolution to cable television". Given this diversity, it would be "our people and the values we hold" that would bind the group, she said.

In its earlier phase, the group could rely on a network of personal ties to ease communications. That network was based on the personal links senior management had established as government scholars or Mindef officers. As useful as it was in the past, that network will not be available on the regional or global stage.

As Ho Ching noted, "to reach out, to be able to operate in totally different environments, in a much more spread out geographical area than just a little dot called Singapore, ST needs to put in place systems that foster the values that we want, and make sure that our people have the ability to read what is going on in the world so we're not caught by surprise. In that sense, we need systems."

ST has been led over the years by inspiring individuals, such as Dr Goh Keng Swee and Philip Yeo – strong leaders who left indelible imprints on the group. To borrow the terminology of one management guru, they were leaders who could 'tell the time' without the aid of a clock, just by looking at the sky – and in Dr Goh's case, it sometimes seemed to those who worked closely with him that he could 'tell the time' even when the sky was dark and gloomy. But in aiming to be a full-blown MNC spread across several industries and countries and time-zones,

The forecast looks bright for the Wuxi-Singapore Industrial Park. Tenants of the world-class high-tech park include renowned MNCs such as Seagate, Siemens, Matsushita and Sumitomo.

ST can no longer rely solely on such a leadership style. The greatest tribute, perhaps, that ST can pay to such remarkable individuals is to recognise that their leadership has wrought an entity that has made their kind of singular inspirational leadership, not obsolete as such, but insufficient for the challenges that lie ahead. ST now is too varied and too complex to be encompassed by any one individual. What it needs is a system and structure that will fit talented individuals into a coherent and agile team; and it needs a clock which will help it 'tell the time' in a world where all the time-zones have become jumbled together in a heap.

This is the challenge that still lay ahead, said Ho Ching, the most important challenge that ST faced. And with a sharp sense of realism that carried with it a hint of the determination that underlies the strength of ST, she said firmly: "We haven't built the clock yet."

ST Value System

Integrity
The integrity of an organisation is the pillar of long-term success, and its foundation lies in our people. It is the sum total of the individual traits of honesty, dedication, and responsibility as professionals and co-workers in a common enterprise of creating value and bringing positive contributions towards a better world.

Value Creation
As individuals, as companies, and as countries, we must bring value to what we do, not just once, but consistently. It is a part of the quest to enhance quality of life through constant thought and application of effort. As individuals we may be good, but with teamwork we can multiply the value we bring.

Courage
To try for the seemingly impossible, to break the mould and to start over again, to look at issues and at ourselves dispassionately, to take responsibility for failure, to take the future into our own hands and to contribute to that small bit of change for the better – courage is the seed for creation and progress.

Commitment
Commitment is the spirit that drives energies positively against seemingly impossible odds to achieve extraordinary results. It sustains drive and keeps our standard flying.

Compassion
In our drive to succeed as individuals and organisations, we will fail to bring value to others unless we empathise and support others in need. Organisations do not have compassion – only people do. A true act of compassion must come as a direct gift from the individual.

Singapore's GLCs: A Class of Their Own

For a free-market purist, the extent to which Singapore's public sector participates in the economy may seem surprising. An astonishing number of the largest companies listed on the Stock Exchange of Singapore are government-linked companies (GLCs). How did this happen? Why, unlike their internationally-renowned archetype, have GLCs not been associated with gross inefficiency, bloated bureaucracies, or heavy subsidies?

Singapore's state-owned enterprises fall into two categories: first, statutory boards, which are more autonomous than government departments, but are established by Acts of Parliament and supervised by ministers; and second, GLCs, which are established under the Companies Act, and thus have the same freedom of manoeuvre as private firms.

Some economic historians trace the entrepreneurial energy of Singapore's GLCs to the same traumatic event that prompted the launch of National Service and the defence industry: Britain's announcement in 1967 that it was withdrawing "east of Suez". British bases in Singapore accounted for one-fifth of Singapore's workforce and 13 percent of its GDP. To make up for the shortfall, the government began to take a pioneering role in the economy, especially in industries where the initial capital investment was too large for the private sector. The number of wholly- or partially-owned government companies rose from about a dozen in the mid-1960s, to 70 in the early 1980s. By 1987, the Public Sector Divestment Committee counted 505 GLCs, including subsidiaries and associated companies.

The GLCs were set up for different reasons. In the case of public transport, the government took over the bus companies after a breakdown in the services provided by private companies. In some other cases, history played a role. The British withdrawal, for example, left a large naval facility which had to be converted to commercial use, and Sembawang Shipyard was among the results.

Though the government is involved in the appointment of the CEOs of the larger GLCs, the Cabinet does not intervene in the management of the companies. The boards of GLCs also exercise only nominal authority. The real control rests with the management of these enterprises. As Dr Goh Keng Swee has explained: "As long as the managers are competent, the function of the board and ministries remains largely one of support and encouragement. The commercial banks to whom these enterprises apply for loans in fact exercise more control over their affairs." The corollary of this authority is that managers are held accountable for the performance of their businesses.

One of the strengths of GLCs has been their access to the pool of government scholars, spotted in their teens for their outstanding academic results. As Dr Goh noted, many scholars were posted to GLCs when they returned from their studies in top universities around the world. "[That] is why there is a higher concentration of talent in these companies than in local private enterprises." Today, GLCs compete with the government in offering overseas scholarships to outstanding candidates.

According to economist Professor Mukul Asher of the National

University of Singapore, statutory boards and GLCs have played a valuable role in absorbing technology and spearheading research and development, and have thus become a counterweight to the multinational corporations that otherwise dominate the economy.

However, not all observers are enamoured of GLCs. Critics have alleged that by dominating certain markets and manpower resources, GLCs have crowded out local entrepreneurs. This complaint has lessened over the years as Singapore companies found opportunities for growth in the booming Asia-Pacific region.

Observers have also looked askance at the civil service backgrounds of many of the directors and managers of such enterprises, stereotyping them as cautious and risk-averse. The record, however, suggests that many of Singapore's civil servants have actually been highly successful managers of enterprises. J Y Pillay at SIA, and Philip Yeo at ST, are only two among many examples.

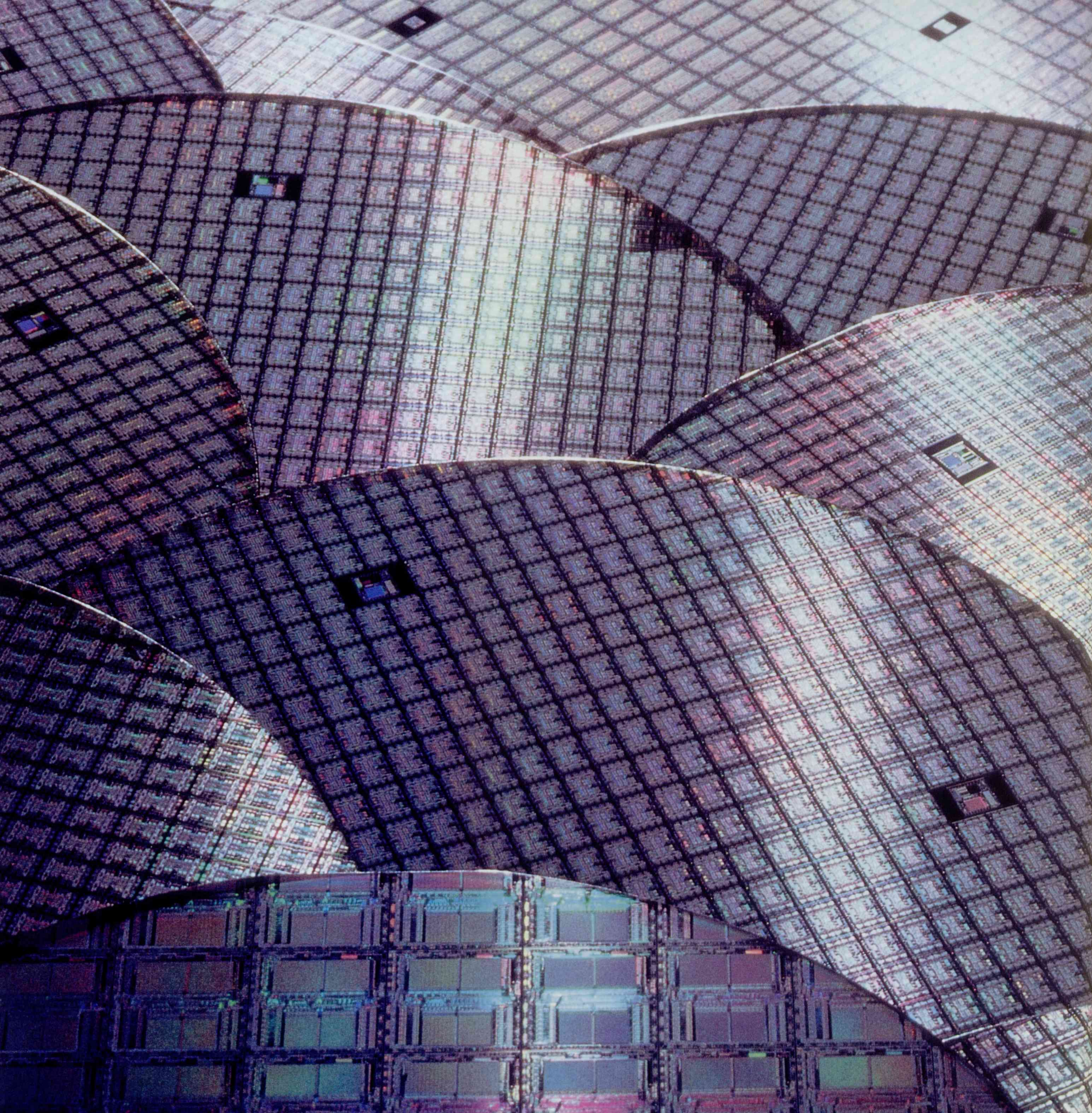
Finally, state-owned enterprises have been criticised for lacking the "reality check" that private sector managers face, whether from the stock market, or the knowledge that their own money is at risk.

Strangely enough, such criticisms, though often unfair, were factors in the privatisation of GLCs. As Dr Goh explained, "one important element [behind privatisation] is the complaint that the enterprises engage in unnecessary and unfair competition with the private sector. ... It is therefore prudent to sell off the holdings even though the allegations are false." The privatisation drive picked up after the 1987 Report of the Public Sector Divestment Committee which urged that the private sector be used as the engine of economic growth. Later, when Mr Goh Chok Tong's government made the creation of an asset-owning citizenry a major policy objective, there was an added reason for offering equity in GLCs to the public.

For the enterprises themselves, privatisation led to greater public scrutiny of their performance. The stock exchange, for instance, requires six monthly reports, and thus "performs a much-needed function of supervision of the state-owned enterprises", said Dr Goh.

But just as Singapore's state-owned enterprises are different from their counterparts in many other societies, so too their privatisation was of a different character. In many countries, privatisation of state enterprises meant the sale of assets to private companies to enable the new owners to restructure loss-making businesses. But in Singapore's case, it was different. The enterprises that were privatised were not failing ventures, but successful ones.

Indeed, the successful listing of so many GLCs confirmed the justice of a statement that Dr Goh once made: "The truth is that state-owned enterprises are an important vehicle of entrepreneurship in Singapore". The successful transformation of these enterprises into listed vehicles is evidence that the market now holds the same view of Singapore's GLCs.



CHAPTER SIX
AD ASTRA PER ASPERA

Singapore Technologies in the late 1990s is an almost unrecognisable creature when compared with the infant defence companies of the 1960s. But certain common themes emerge in this 30-year history. These themes not only suggest a continuity of identity and purpose, but also point to values that will continue to remain instrumental as ST fashions a future for itself as a full-fledged multinational.

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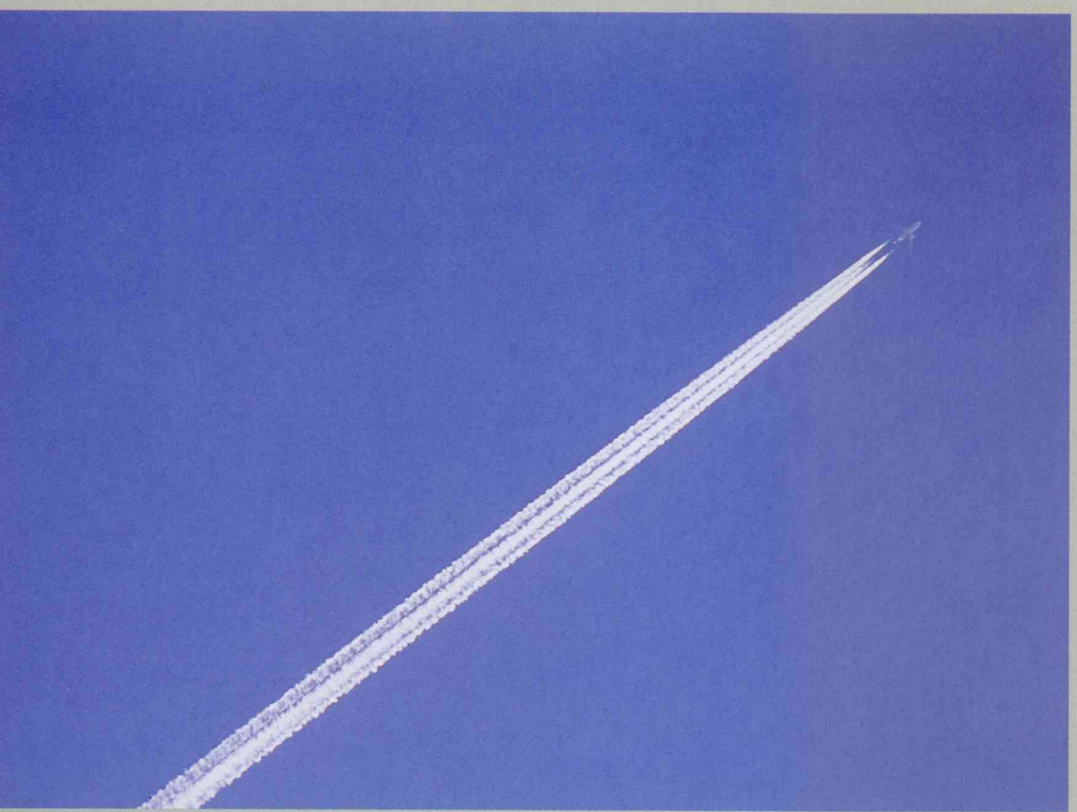


AD ASTRA PER ASPERA

Ah, but a man's reach should exceed his grasp,
Or what's a heaven for?

Robert Browning

What images return in the mind's eye as we review the past? What are the memories that grip and hold us in their embrace?

The family album of Singapore Technologies contains a bewildering array of images. The early pages are filled with stark black-and-white photographs, revealing grim faced men and women in simple clothes. There is nothing prepossessing about these people, nothing grandiloquent, but there is nothing mean about them either. Unconsciously, but clearly recognisable in the light of the future, they exude a certain seriousness of intent. And this despite their dreary surroundings – a zinc roofed shed, a desolate beach, a raw construction site.

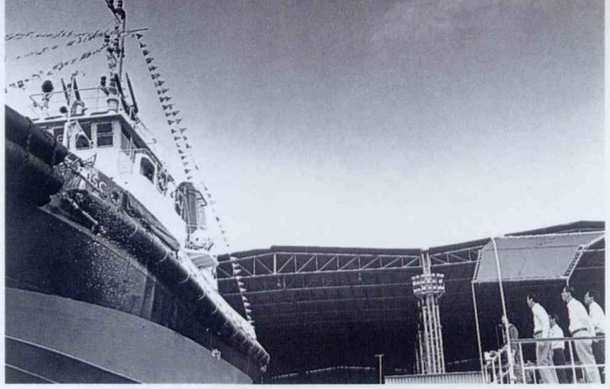
Soon, the photographs, still black and white, show the surroundings resolve themselves into recognisable shapes – ordnance factories, automotive repair works, electrical workshops, a dockyard. As we turn the pages further, and get our first look at the products that issue from the factories and workshops and dockyards, a hint of colour creeps into the photographs. We see pictures of precision engineered cartridges, mortars and howitzers, naval patrol craft and armoured vehicles. We notice a sprightly confidence in the men and women as they go about their tasks.

But slowly but surely, as the evidence of colour increases, the military images thin out – or rather, they become indistinguishable from the non-military ones. For the same dockyard turning out missile corvettes is turning out container ships; the same electronic workshops equipping the SAF with communications systems are installing automation systems at Changi Airport; the same company, ST Aero, that is offering an upgrade package for the F-5E, is also making a civilian five-seater helicopter, the EC120.

As we turn the pages further, and get closer to the present, the colours become brighter and more vivacious; and the sheer range of activities and people, no longer just Singaporeans, become bewilderingly diverse. As though someone just tipped over the cornucopia of plenty, pictures of prosperity trundle out by the dozens. The smiles of people are broad, the glass and steel buildings glint in the sun. We see photographs of aircraft hangars and flight simulators, packaged foods and supermarkets, telecommunication satellites and medical diagnostic equipment, beach resorts, sprawling industrial parks, and semiconductor wafer plants manned by people dressed in surgical suits manipulating robotic arms. ...

The album positively bulges towards the end, and the photographs, all in technicolour now, spill out over the table and floor.

But as inspiring as the album is, as gratifying as the evidence of ST's success, all that the album represents can disappear in the twinkling of an eye. Companies, more imposing than Singapore Technologies, have disappeared before. Whole countries, even great empires, far more powerful than Singapore will ever be, have sunk below the waterline. Singapore Technologies' family album could become a cautionary tale for someone else. Of what use, then, would this impressive record of the past be?



The launch of the "Sea Terrier", an 1840 HP Tractor Tug, built by ST Shipbuilding for Sembawang Towing Company.

Lim Ming Seong and Dr Yeo Ning Hong (right), then Minister for Defence, at the opening of SAMCO (now ST Aerospace Engineering) in 1982.

But the past is not useless – not if we remain wise enough to hear in it the melody, the strain, that can carry us into the future. ST's past is a usable past. Secreted in its record, but clearly legible, are reminders of what it takes to succeed. If ST remains faithful to the lessons of this past, while being open to the new experiences that come its way, it can hope to meet the challenges the future holds, and beat them.

Singapore Technologies can continue then, as before, to reach for the stars through strenuous effort – *Ad astra per aspera*.

The transformation of the Singapore Technologies group over the last three decades has been momentous, both in terms of its size and in the nature of its activities. Between 1967 and 1996 – within a generation – turnover rocketed from less than S$2 million to S$4.5 billion, assets increased more than 700-fold to S$13.7 billion, the number of employees jumped from just over 100 to more than 21,000, the contribution of overseas operations to total revenue rose from zero to 14 percent, and the proportion of export sales to total sales rose from virtually nothing to 46 percent.

How did this happen and why? What are the chief lessons that we can draw from the past thirty years? There are many, but the key attributes of ST's success thus far, can be summarised as follows:

ST is not a company built upon a single grand vision, a single overarching plan that guided it every step of the way. It is a company that learned as it expanded. If it is a visionary company – and it has done some remarkable things to justify that adjective – it is not because it cleaved to a particular vision, a specific plan which might easily have turned into a straitjacket, but because it paid attention to the process of visioning itself, of cultivating foresight. It could, therefore, respond quickly to changing circumstances.

The growth of ST can be likened to a banyan tree that sprouted new branches in all directions. ST grew organically, rather than as a result of a preconceived plan or design.

No doubt, when Singapore's economic visionary, Dr Goh Keng Swee, established Chartered Industries back in 1967 to help cater to Singapore's defence needs, there was a gleam in his eye. He deliberately did not constitute CIS as an in-house arsenal which would operate on a cost-plus basis, even though such an arsenal could have made a steady, if modest, living by focusing on one area. It could have, to this day, carried on building weapons systems, maintaining and repairing vehicles, ships and planes, and doing other subcontracting work for the SAF.

But CIS – and later, ST – never allowed itself to be lulled into comfort or get stuck in a groove. It always challenged itself, asking questions like: What else should we be doing? What is going on around us, and how can we take advantage of it? What new avenues can we open up? ST

has never been afraid to act on its hunches, to take calculated risks, to experiment, to defy conventional wisdom, to reinvent itself.

Dr Goh could not have foreseen in 1967 what sort of companies CIS would evolve into, or where and how far they would go. Indeed, if he had attempted to impose on those early companies a particular path, a detailed road-map, the map would almost certainly have led the companies astray. The group's diversifications into such areas as semiconductors, industrial parks, hotels, overseas housing projects, satellite communications, financial services, and recently, cybermarketing, were dictated by unforeseeable and ever-changing economic currents. In fact, many of these ventures were never planned, but were the result of an aggressive opportunism, a swift-footed agility. Such ventures might never have been undertaken even – and indeed, they weren't by companies that started out with similar resources and around the same time as CIS – if Singapore Technologies had not cultivated agility instead of plans, energy instead of safety, *visioning* instead of visions.

Lim Ai Tee

The Office Attendant at CIS since 1970, Lim has worked with "more or less a hundred people" over the years. She has stayed on because "the job is good, the bosses are pleasant". For 27 years, Lim, who lives near CIS, has walked to work everyday. She recalls how in the early days there was nothing much besides the CIS factory along Boon Lay Road. Now there is an MRT station, a shopping centre and HDB flats. "It was very rural then. So much has changed. The roads are now completely different."

Worker at CIS assembling fuses.

Wee Siew Kim

Wee joined ST Aero in 1984, and has served in various appointments, including Senior Engineer, Regional Director, Vice President (Planning & Finance) and Senior VP (Operations). He is currently Senior VP, Commercial Business Group, which comprises SASCO, MAE and Airline Rotables Ltd. He is concurrently President of SASCO, Chairman of Asia-Pacific Aviation Services, GM of Singapore-China Merchant Aviation Holdings, and a member of the boards of Airline Rotables, Turbine Overhaul Services, and Asian Aerospace Pte Ltd. Wee has a Bachelor's in Aeronautical Engineering from the Imperial College of Science and Technology, University of London, and an MBA from Stanford University, US.

ST Aviation Services Company, also known as SASCO, is part of ST Aero's Commercial Business Group, which also includes SASCO's sister company, ST Mobile Aerospace Engineering in Alabama, US, and Airline Rotables Ltd, an aircraft component leasing subsidiary.

ST has been an entrepreneurial company. It took calculated risks; it reached beyond its grasp. It was always willing to ask itself when confronted by challenges: "Why not?"

Like a young and brash entrepreneur, full of vim and vigour, ST went ahead and took the plunge when others would have balked; and it often did so without an established trail to follow, sometimes without even a blueprint. Its move into Batam was an example of this. Here was a project that was the first of its kind and was widely thought to be undoable when ST embarked on it. There is general agreement that if feasibility studies had been done, they would have probably borne out that view. Today, the Batamindo Industrial Park is held up as a model to emulate in countries as far afield as India and China.

Other examples of ST's entrepreneurial spirit are its forays into the leisure business and hoteliering, in places as far off the beaten track as Bintan and Myanmar; its expansion within the food business, including the development of the world's largest pig farm near Shanghai; its diversification into medical equipment manufacturing and its recent move into regional property development.

In executing its ventures, ST has shown an entrepreneur's fleet-footedness, an ability to change course midstream and to improvise. This was evident from the beginning in CIS's ability to retool its military-related activities for non-military purposes. These qualities were also dramatically reflected in the case of CSM, which was able to transform itself virtually overnight from being a captive producer of

Agilis Communication Technologies, which has won an award from Singapore's National Science and Technology Board, is a major world producer of Very Small Aperture Terminal Outdoor Units for satellite communication.

semiconductors to being a foundry for multiple customers and users – an unusual step at the time, especially for a company that was just beginning to play in the major leagues of high-tech industries.

The experience of CSM – and that of numerous other ST enterprises like ST Shipbuilding, ST E&E and ST Aero – also bears out another trait that is part of ST's nature: doggedness and courage of conviction. It has consistently succeeded in seeing its ventures through to the end, often despite formidable obstacles and even when closure would have been easy to justify.

Entrepreneurship is, in a sense a formal part of ST's culture. The group's approach has always been to find entrepreneurial people, to place them in a corporate environment and to give them autonomy, making them feel it's their own business. There is even talk in some ST companies of formally transferring ownership to managers so they can follow their own dreams.

Thus it is that ST has not evolved into a corporate bureaucracy as so many companies of equivalent size have done. It has deliberately resisted centralism and homogeneity. Group headquarters remains a lean and sparse operation, more like the OHQ of a rapid deployment force than a GHQ of a standing army in the field. The group as a whole is more like a collection of sleek fighting ships, each permitted to set its own course by the scent of battle in its own theatre of operation, rather than a lumbering aircraft carrier battle-group, carrying everything and everybody to the same destination.

It is true that unlike the typical small entrepreneur, the individual member companies of the ST group have had ready access to significant resources, or feel they have had such access. The mothership, group OHQ, has not cosseted its offsprings, of course, but it has been generous in its support. Still, these member companies have had aspirations far in excess of the resources they could command – not only financial, but also technological and human. On a few occasions, this tendency to overreach led to disaster. But at other times – as with Batam and CSM in recent times, and the FH 88 howitzer and the Ultimax assault weapon in the past – this attitude led to successes that surpassed the expectations even of insiders. Its ability to stretch itself beyond presumed limits, and not snap, has given ST much of its entrepreneurial confidence.

Workers preparing the golf course at Batamindo Executive Village.

Cyborgs

Many of us wear spectacles or contact lenses. Some of us with hearing problems wear hearing aids; some of us wear dentures; and almost all of us have at least one or two teeth that have been filled, filed or capped.

Spectacles, dentures and hearing aids, however, are only among the more familiar accoutrements of humanity. There are people walking around with pacemakers in their hearts, and a few even have artificial hearts. Some have 'improved' noses and eyes, and others have had their chins tucked, their lips sucked, their breasts lifted and the tops of their heads implanted with hair they ought not to have. Indeed, there is hardly a human being left in industrialised countries whose body parts have not been improved by technology in one way or another.

And beyond these medical or quasi-medical contraptions and procedures, there is an extraordinary number of other products that extend the range and reach of our humanity. Cars, trains, buses, airplanes extend our leg muscles and have vanquished space. Telephones (line and cellular), faxes, e-mail, and soon, voice e-mail, extend our ears and tongues, and have vanquished the necessity for face-to-face encounters. Refrigeration has transformed dietary habits; and electrical lights have extended daylight. We can now work, play and eat 'round the clock; and studies have shown that lighting has changed our sleeping habits, for we sleep now on average about two to four hours less than our great-great-grand parents did a century ago.

Vacuum cleaners, washing machines, ovens (gas, electrical and microwave) and a whole host of other household appliances have liberated women from the home. We don't have to chop wood now for fires, we don't have to draw water from wells for baths, we don't have to personally dispose of our bodily wastes. A flick of the switch, a turn of the knob, a pull of the handle and a press of the button are enough to perform essential functions which used to occupy hours in the lives of our ancestors.

Indeed, switches and buttons are everywhere. A flick of the switch is enough to transform the weather – cool air-conditioning in the tropics; warm air-conditioning in the arctic. And a press of the button will suffice to bring entertainment to our homes via television, radio, VCR, cable, tape-deck, CD-player, etc. We no longer have to entertain ourselves (singing has declined throughout the world); we are entertained (being sung to has increased throughout the world, and is now a multibillion dollar industry).

Indeed, given the number of instruments – mechanical, optical, auditory, visual, electronic, medical, etc – to which we are either attached or are attached to us, how is it possible to tell what is human and what is machine?

Is a person with an artificial heart still a human or is he a machine? A stupid question? Well, yes, it *is* a stupid question, but the answer all of us will undoubtedly give – namely, that the person with an artificial heart is human! – begs the question. For if a human with an artificial heart remains human, what is the essence of the human? How can we tell what is natural and organic, when the 'natural' and 'organic' continues to exist

only because of an 'inorganic' contraption, an 'unnatural' artificial heart?

In fact, humanity has become so dependent on technology, technology may well have become the essence of humanity. Donna Harraway, for example, a historian of ideas at the University of California, has theorised that all of us – or at least, those of us who belong to the industrialised world – are neither human nor machine, but are human *and* machine, cyborgs. The bionic man and woman, in other words, are not figures in science fiction; *they* are *us*.

Other thinkers, including the historian Arnold Toynbee and the palaeontologist Teilhard de Chardin, have argued that technology has replaced biology as the mechanism of human evolution. Though hundreds of thousands of years have lapsed since the first of our species of humanoids was born, we have remained biologically the same throughout this period. Culture and technology, however, have made us so different from the first humanoids that we might as well belong to totally different species. This process of species differentiation via cultural differentiation is likely to accelerate even further in the coming decades and centuries.

All the mechanics of biological evolution – natural selection, the survival of the fittest, species differentiation, and so on– will then be replicated on the level of technology. It will become increasingly difficult to sustain definitions of humanity based solely on our so-called 'essential' attributes. The 'superstructures' of humanity – knowledges, modes of organisation and techniques of production – will become as basic, if not more so, than the 'bases' of humanity.

It is difficult for most of us to see this straight because we are gripped by the conviction that human beings are independent of their creations. 'Man makes technology', we like to say, but we do not say that 'technology makes man'. We like to assert the autonomy of human nature; we are loath to admit that human identity is conditional.

Obviously, we cannot give up on the belief that there is something essential about human nature. That belief is the basis of values. There can be no such thing as culture, philosophy and religion; no such thing as love, respect or loyalty, all the values we hold valuable, without believing in the essential worth of human beings.

It remains a fact nevertheless that human identity will be shaped and re-shaped at a dizzying rate by technology. To refuse to accommodate our identities, our habits and our cultures to the demands of technology is a little like the first humanoid refusing to come down from the tree because walking with two legs on *terra firma* contradicts the primateness of being a primate.

Technology is no longer just a luxury, an appendage to humanity, but the very environment in which humanity must either suspire or expire.

Previous Spread
Singapore Technologies was present at the creation of a nation, and its own growth in many ways has paralleled that of the country: from its early days as a fledgling third world defence outfit to its present state as a technology-based multinational headquartered in Singapore.

Changi Airport Terminal 2, another massive project where STIC played an instrumental role. STIC exceeded expectations for 1996 with a net profit of S$66.5 million, an increase of 22 percent over the previous year's figure. While operations in Singapore accounted for 80 percent of STIC's profit in 1996, this proportion is expected to fall to 50 percent as the full benefits of its regional investments come on stream.

ST is a company that grew by leveraging its skills, its competencies, to move into new areas of activity. It leveraged, too, the talents of others, used other companies that already were doing what it wanted to do, so as to pole-vault itself into emerging industries.

One of the keys to ST's success has been its ability to leverage the skills of its staff and transfer them across industries. Thus many of the same people who built naval patrol craft later switched to building container ships; the engineers who worked on radar and military command and control systems turned their hand to developing communications satellite sub-systems for the commercial market and the supervisory control systems of Singapore's Mass Rapid Transit; and those who learnt to construct military facilities are today building industrial parks.

ST was able to transfer skills from one industry or activity to another because it never typecast itself as a specialist in any narrow sense. Unlike many other companies, ST focused on what its people knew, rather than on the particular industries they happened to be serving at any given moment. In other words, ST's core competencies were always defined, not by target industries, but by the skills of its staff. Consequently, its trajectory of growth was governed, not by an abstract notion of the synergies to be gained from diversification, but rather, by the productive exploitation of the skills its people possessed.

This approach required ST to pay as much attention to the accumulation of knowledge as it did to the accumulation of capital. When Dr Goh insisted that CIS try to make subassembly parts of the M-16 rifle, what he was after was not just the specific parts but the knowledge that produced the parts. Learning to make firing pins that can fit into any M-16 rifle requires precision engineering and a capacity for fine calibration of tools and die – ultimately, skills far more productive than the immediate products in question. In the long line of descent from the first ordnance products to semiconductors, the knowledge acquired in producing those firing pins arguably played a greater role in CSM's success than all the millions that were sunk into its plants.

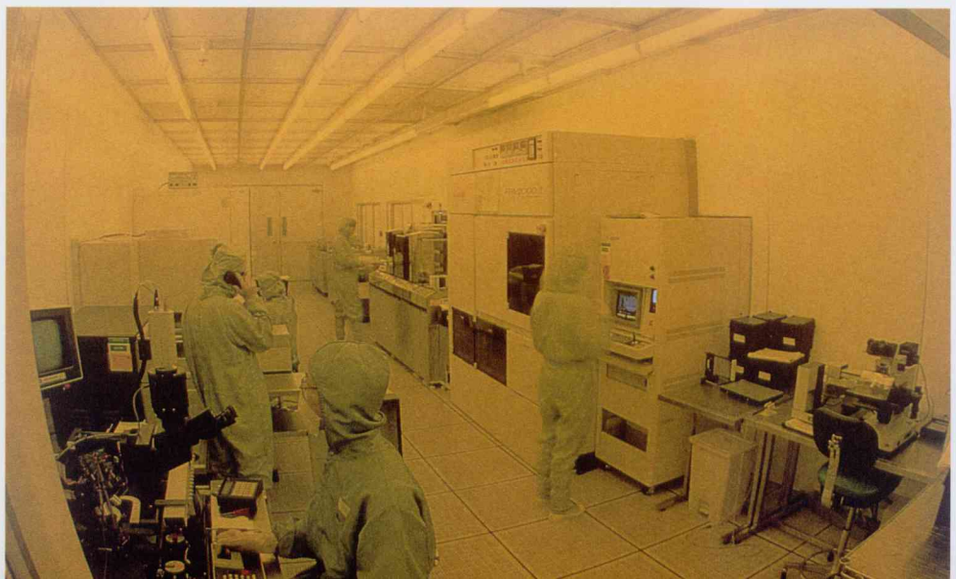
The philosophy underlying this approach has been, and will continue to be, crucial to ST's success, not to mention Singapore's. It implies treating knowledge itself as a locus of production – for knowledge begets knowledge; one learns by learning. This recognition was instrumental in the past, and will become even more instrumental in the future, when knowledge-based industries and information technology become the staple of Singapore's economy. This is the reason why the ST of today invests so much in the development of human resources, and is intent upon attracting talent from throughout the world.

ST has also displayed, from the earliest days in CIS or ODE to the present, a shrewdness in leveraging the skills and the resources of others. In Batam, for example, it was able to position itself to benefit from the regional ambitions of multinational corporations. It has also gained from strategic partnerships in a range of industries, including

aeronautics, food, building automation systems, semiconductors, medical instruments, shipbuilding, and property. Not all of these partnerships have functioned smoothly – although most have – but in the process, ST has learned much about what it takes to make corporate partnerships a success. This understanding will be a valuable asset in the future, when the ability to forge and maintain strategic partnerships will be of critical importance in industries like semiconductors, which require multi-billion dollar capital investments and R&D expenditures.

Sam Lee

Lee is Deputy Director in charge of Special Projects at ST. He has been with the company for over 22 years, starting as an industrial engineering manager with CIS in 1974. For Lee, one of the rewards of working in ST has been watching it transform from a company dedicated to defence to what it is today. In 1991 he was asked to establish Gateway Technologies, which recruits professionals from overseas for a host of Singapore companies, not just ST. Lee has gained recognition as a Chinese poet, receiving a commendation in 1996 from the Singapore Book Awards for his book of poems, Put on the Sunlight. *His passion for poetry dates back to 1953. Lee said, "I was greatly influenced by my father... he was a teacher and therefore our home was always filled with books".*



A peek at what goes on inside Chartered Semiconductor Manufacturing Ltd, ST's star performer in 1995.

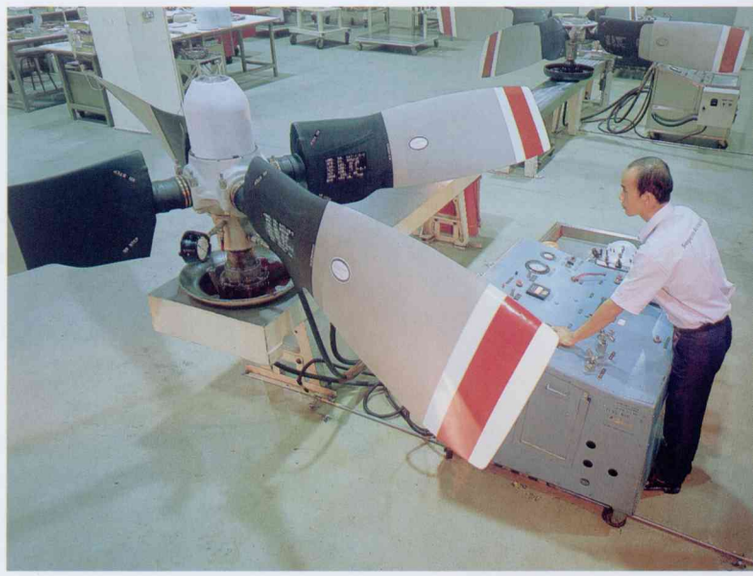
Previous Page
ST Shipbuilding has had its share of trying times, but like the group as a whole, it has learned from its mistakes and bounced back.

ST is a company that has made mistakes, learned from them, and bounced back. It has not been afraid to make mistakes, realising that the only way to avoid making them is not to venture anything, and thereby avoid taking risks altogether.

Like any entrepreneurial company, the ST group has made its share of mistakes, some of them very expensive. In retrospect, some of these mistakes seem elementary – as when CEI failed to develop the marketing capabilities to complement its engineering skills in the mid-1980s and was left with large unsold inventories; when ST Shipbuilding underpriced the ships it sold in the late 1970s, resulting in huge cost overruns; or when ST subsidiaries tried to acquire technologies overseas in the 1980s without developing the vehicles to absorb these technologies. Mistakes like these are examples of the price entrepreneurial companies sometimes have to pay when they go into new businesses without a track record or a blueprint.

In most cases, ST has been able to learn from the mistakes it has made: CEI, ST Shipbuilding and the technology subsidiaries subsequently bounced back from adversity, a theme that recurs frequently in ST's history.

No doubt, ST companies will make mistakes in the future also, and perhaps more frequently than less entrepreneurial companies. The way the group sees it, the point is not whether mistakes are made, but as Ho Ching pointed out: "The key thing is how fast we recognise that something is a problem that needs to be solved, how fast we solve it, how fast we recover and how well we learn the lesson not to repeat the same mistake – yet without going to the other extreme of not doing anything at all. If you don't do anything you make no mistakes. To build, we need to take risks, live with failure and learn from failure and rebuild from ashes."



After suffering a loss of S$48 million in 1995, ST Aero made an impressive turnaround in 1996 with a net profit of S$28 million. Among the factors in the company's recovery was its sustained marketing efforts in the US, and the strong performance of its maintenance and overhaul service arms.

Workers loading a container onto a truck in Batam. Part of the reason for the success of Batamindo Industrial Park is the island's excellent transportation infrastructure.

国泰民安

Prosperity for Our Country
Peace for Our People

ST is, indeed, a government-linked company. Far from being something to be embarrassed about, the fact that it was and is and will probably remain a GLC is a crucial element in its success. Especially in the early days, its biggest customer was also its biggest investor. It had a pool of talented people in Mindef and government to draw upon; and it benefited enormously from being part of Singapore Inc – that loosely-coordinated but highly mobile force that links the resources of the nation for competitive advantage in the global marketplace. But though a GLC, ST has had considerable freedom of action, more so than many private companies, including MNCs. And in all probability, the intangible benefits of being a GLC will decline in the future, as ST's operations become globalised.

Some observers of the Singapore corporate scene have suggested that a major reason for ST's growth and success has been its links with the Singapore government. They are not wrong. ST's government links have indeed provided it with influence, access to resources, and in the early days, a captive market for its ordnance. Companies in the ST group, like STIC when developing industrial parks overseas, have benefited also from the assistance provided by agencies of the government, such as the Economic Development Board and the Monetary Authority of Singapore.

But two central points need to be understood. First, ST is a GLC precisely because there would have been no ST if it had *not* been a GLC. Private sector entrepreneurs were not willing to go into many of the businesses that ST undertook. These businesses simply would not have existed if a GLC had not established them. That is a stark fact of history.

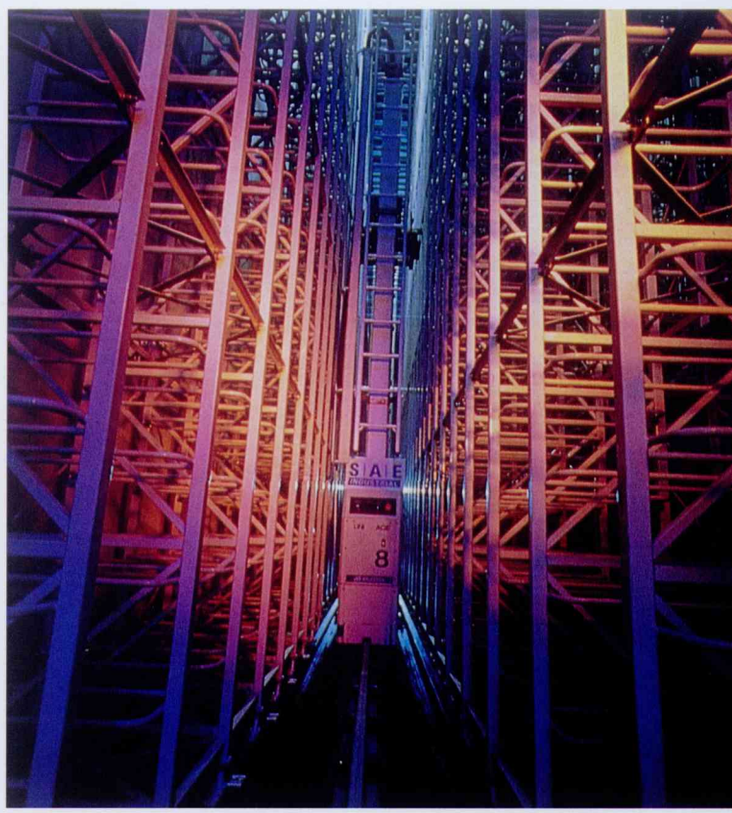
As Dr Goh has pointed out, "Singapore's economic growth suffered from [its] history. Singapore, under British colonial rule, never had a significant manufacturing sector. It lived by trade, collecting the tropical produce of the archipelago into its port, and then grading it if necessary, and re-exporting to the countries of the industrial world; and on the other hand, buying consumer goods, and re-exporting them to the archipelago. [As a result] many local entrepreneurs [were] good at shipping, trade, and banking, but not manufacturing." In the absence of an indigenous manufacturing base, Singapore's industrialisation had to be jump-started by foreign MNCs, on the one hand, and local GLCs, on the other. As Dr Goh bluntly put it: "The truth is that state-owned enterprises are an important vehicle of entrepreneurship in Singapore."

Second, in the final analysis, GLCs like ST are successful, not because of their government links, but because they are run on commercial principles. The hand of the government is not visible in the actual running of ST and its group of companies. The government generally takes a *laissez-faire* attitude, and has no more than a superficial knowledge of the companies' activities. As Philip Yeo suggested, successive chairmen of ST and the heads of the group's individual companies have had more operational autonomy than the CEO of a typical multinational corporation in Singapore.

From the earliest days, despite being a GLC, ST's subsidiaries were required to bid for government contracts in competition with other companies, both local and foreign – and sometimes, they lost. There were intangible benefits to being a GLC, but these were not of a kind that guaranteed success. There are many GLCs in Singapore that did not grow as fast or diversify as boldly as ST did.

Moreover, the intangible benefits that flowed from ST's government links have had their limits, especially in the later years. There were even times when ST's government links worked to its disadvantage. When STIC tried to raise commercial financing for the Batamindo Industrial Park, for example, many banks refused, on the ground that the project was 'national service', and as such, ST was pursuing it for political reasons, not commercial ones. Unencumbered by the image of being a 'government company', a private conglomerate might have found it easier to raise the necessary financing.

During the rest of the 1990s, the mileage that ST can obtain from its government links will shrink even further. It is now a player in the international market, where skills and ideas matter far more than local connections or financial clout. This does not mean that ST will not benefit overseas from the 'stamp of quality' that being associated with the government of Singapore brings – and it will be foolish of ST to divest itself of that stamp – but it does mean that it will have to prove itself on the world stage on its own terms. The 'stamp of quality' can open doors, but it doesn't guarantee invitations to stay for dinner.



An auto-storage and retrieval system. SAE Industrial Systems does customised design and integration of automated storage and retrieval systems, using automated guided vehicles.

Looking Ahead

Ho Ching, the President and CEO of Singapore Technologies Pte Ltd, is a person with whom it is easy to talk. She is persuasive, lucid, brushes off cant with a good-natured laugh and shrug of the shoulder, but she is a careful listener and makes her interlocutors feel they are quite welcomed to disagree with her.

The first thing she told her questioners at the following interview was: "Please don't call me Madam Ho; Ho Ching is just fine." And the last thing was: "ST has a long way to go."

Ho Ching was proud of ST's successes, frank about its failures, and realistic about the difficulties and challenges that lay ahead. As for the writers' own positive assessment of ST's past and future, she was only willing to allow: "I agree with 80 percent of what you say."

She was educated at the University of Singapore, and later, at Stanford University. After receiving her Bachelor of Electrical Engineering in 1976, she joined Mindef as an engineer. She left Mindef in 1987 to join the ST group of companies, where she worked in Singapore Technology Corporation, then the umbrella of the ordnance and automotive companies of the group, and Singapore Technologies Ventures, a grouping of new ventures, before assuming her present position at group OHQ.

She shared her views about the company's approach to business, its character and its spirit, its future and her own role.

On ST's approach to business
It's nice to have a theoretical framework that's perfect, but in business you can't. Things change, things move. If 80 percent is in the ballpark, you take a risk with the 20 percent that isn't. You can't wait for everything to be perfect. In any business, there are always untidy edges. It's the ability to tolerate this untidiness that, I think, gives us the flexibility to move and to reshape ourselves.

Then there's this element of the maverick in us. If the group is too full of mavericks, it will become anarchic. But if we have a flavour of the unusual, the maverick, then we may see something which conventional wisdom

would overlook. That is why we tolerate quirks all over the place, as long as the price is not the failure of the whole ship.

I have the confidence – a confidence shared by many in the group, a confidence that has been justified many times – that we are capable of doing things which are more complex and more demanding than our resources would permit.

Whether it's a factory or an industrial park, we have the confidence that we can deliver. It is a matter of putting the right team together. Sometimes we do it faster, sometimes slower. But we deliver.

On success and failure

There is an old Chinese story about an old man who lost his horse. All his neighbours said, "Oh, what bad luck!" And he said, "No, it's not necessarily bad luck." And sure enough, a week later, the horse came back with a whole brood of mares. And the neighbours said, "What good luck!" And he said, "It's not necessarily good luck."

Some days later, the old man's son was trying to tame one of the mares and he fell down and broke his leg. And the neighbours said, "What bad luck!" And the man said, "It's not necessarily bad luck." Then there was a war and all able-bodied men were called up to fight, and the neighbours said to the old man, "What good luck, your son is lame and therefore won't be called up." And the man said, "It's not necessarily good luck...".

I don't look at failures and successes as isolated events. During the mid-1980s, we thought that one of the keys to our future was technology transfer. So we started a venture capital outfit in order to acquire technology, and made a lot of investments in companies overseas. But we found that though one could get access to technology that way, if you have no receptacle to receive the technology, then there's no technology acquisition. And if you have a weak company that is incapable of leveraging on the technology you acquire, you also fail. In the end, we found we acquired very little technology transfer this way, and we suffered losses.

But we learnt something in the process. Had we not made those mistakes, there are a lot of capabilities we now have that we would not have had otherwise. For example, we probably would not have been able to go into semiconductors. And if we hadn't gone in, the EDB would probably not have been able to attract any semiconductor investments into Singapore either. So, by a series of mistakes, we created for ourselves an opportunity to go into a business which can, like the petroleum industry, be a major contributor to the whole Singapore economy.

On the scope of ST's future activities

We can't do everything. If we try, we'll do nothing well. Basically, the five areas that we are looking at are: technology, engineering, infrastructure, property, and finance.

We will go into those areas where we feel, first, that there is a large enough market potential for us to grow into a significant player; second, where we can add enough value to be able to be competitive; and third, if it's a business where there's an opportunity to be a number one, number two or number three player, either in the region or internationally. If it's a business that is confined to Singapore we would say no, except, perhaps, if it's in the defence area. Local businesses are best left to somebody else to do.

So, on the whole, we will continue to expand either organically or by going into something completely new.

But in certain areas, we will be consolidating, or even shrinking. When you have companies that go back 30 years, you either find that there are lots of unpolished jewels with lots of underutilised assets or that there are many cobwebs that need to be cleaned up.

In our engineering businesses we have successful and, by and large, healthy companies. But these are companies which have got large parts of their operations in defence and they will need to change and reshape. It may not make sense for us to continue manufacturing small arms in Singapore. It may not even make sense for us to make artillery guns in Singapore, even though we pride ourselves on being able to design products that are equal to the best in the world. It may be that we need to concentrate on high value-added defence systems and systems integration, rather than the manufacture of defence products *per se*, which can be done elsewhere.

So in the case of these companies, I think we need to take a hard look at their long-term capabilities, at what strengths we should focus on and what we should outsource.

On ST's transformation into a global company

We will be a multinational company headquartered in Singapore, but we will have to be cosmopolitan because the businesses that we want to go into, the way we want to grow them, and the targets we have set, depend on our ability to tap markets beyond Singapore. Today, just over half of our sales are in Singapore. By the year 2000, only one-third of our sales will be in Singapore, another third will be in the US, about 20 percent will be in Asia, and the rest will be in Europe. So the shape of the group – its customer profile, its target markets – is going to change tremendously. We will have to reshape ourselves accordingly.

Although we are headquartered in Singapore, it will be not very effective if we keep all our operations in Singapore. We must have international division of labour and place the work where it makes the most competitive sense. We must do what American MNCs do and use the world as our operating base. To do that, we cannot be sending Singaporeans to China, India, Pakistan or the US.

We must pull in people from all over the world and nurture them as part of our team. To succeed, we are not talking about recruiting the top 15 percent of the graduates from the universities in Singapore. We are competing internationally and so we are talking about being able to recruit, retain, and develop as part of our operating team, the top 15 percent of engineering graduates internationally, particularly from the US, China and India.

And so we must learn how to operate a cosmopolitan culture where nobody needs to feel they are second-class if they're non-Singaporean. I think that's very key. If we can achieve that, I think we can be successful, the way American companies are.

Our ability to compete, to create a truly cosmopolitan company – if we fail in that, then we've failed. If we succeed, maybe we have a 50-50 chance.

On her own role
The fundamental task is to create and build a group in which we can have well-recognised, very well-run international players. To do this will require creating the environment in which people can dare to achieve something which they have not dreamt of achieving before, and giving them the necessary resources and the support. Support is very important, because in good times, everybody will pat you on your back, but in bad times, when people are struggling, that is when support is necessary. That is where I see my role.

Then there is the need to build and develop a management team that can achieve the tasks we have set ourselves. I spend 30 percent of my time looking at human resources, trying to find the current as well as the next generation of leaders for our businesses. We must create a system and a culture – very much like General Electric's – that enables us to identify people, give them the exposure, give them the resources, put them to the test, and enable them to develop. Creating such a system and a culture is, I think, my single most important task.

On the ST spirit
It is a company that dares to take risks. It is a company with a huge can-do spirit. It is a company that is willing to trust its people to take the ball and run, and say to them: if you run into a problem, I'll pick you up and dust you off, and off you go again.

Opposite Page
Products such as TriTech's IC chips exemplify two ST goals: market-oriented technology and value-added business activity.

In 1997, ST derived one-third of its revenues from technology-related activities, one-third from engineering and one-third from property, infrastructure and finance. By the year 2000, this profile will have changed: more than one-half of ST's total revenues will derive from technology; engineering would account for just over one-quarter; and infrastructure and finance would make up the rest.

Typically, ST has set itself ambitious targets. It aims to expand total sales to S$8 billion by the year 2000, from S$3.2 billion in 1995. The bulk of this increase would come from non-defence operations.

ST knows that to achieve these goals, it will need to globalise its operations, particularly in technology and manufacturing-related areas, and move deeper into Asia in the areas of infrastructure, leisure, property and finance.

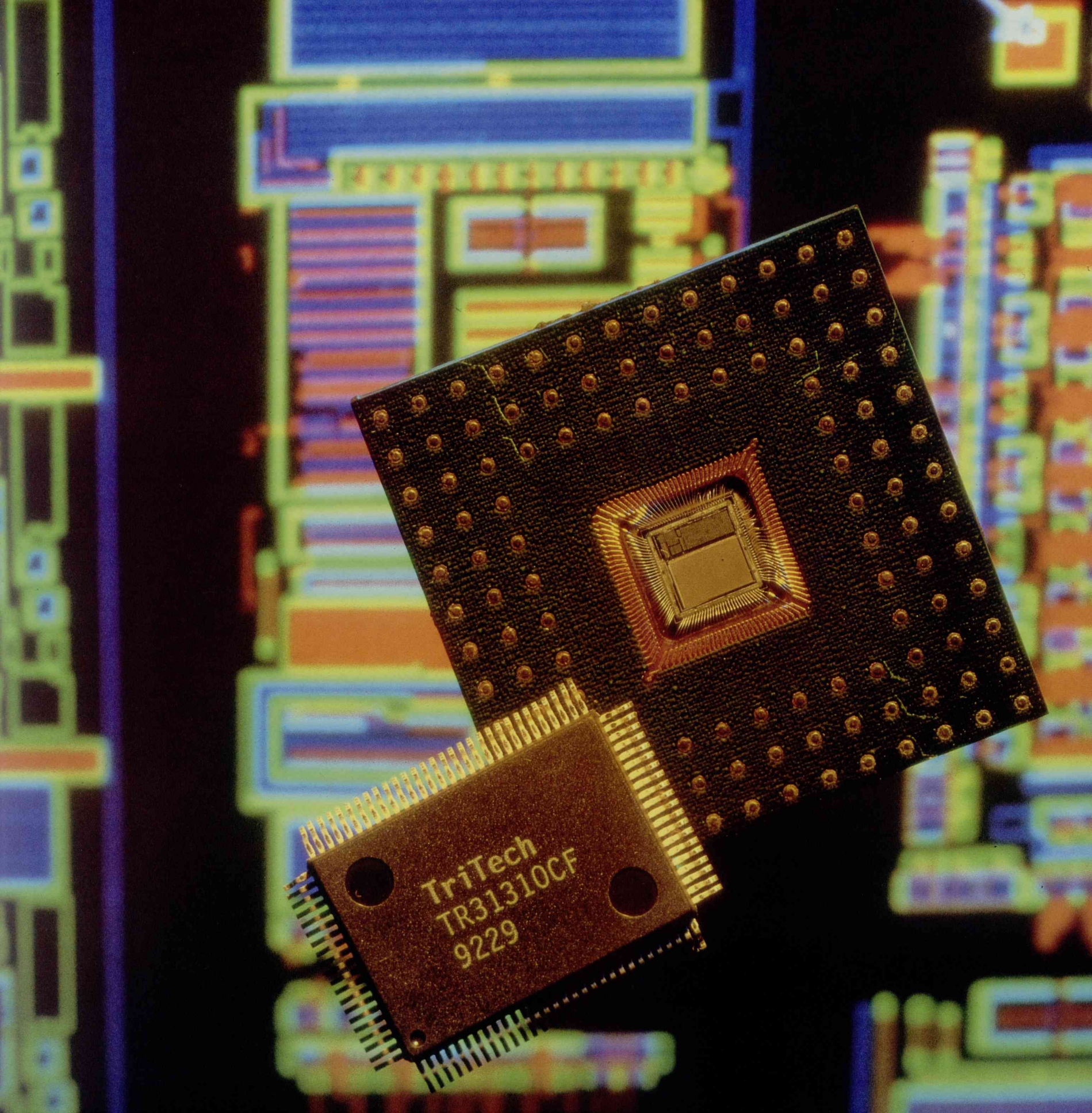
It knows it will have to brace itself for many changes. Some of its traditional engineering-related businesses may need to be restructured and pruned; in other areas, such as finance and infrastructure, it will need to develop new capabilities to deal with the challenges of booming Asian economies. And in technology-related areas, it will have to invest heavily in both physical and human resources to remain on the cutting edge.

ST knows, therefore, that its future is going to be tough. As it globalises its operations, it will have to globalise its staff and its corporate culture. It will remain a Singaporean company to the extent that it will be headquartered in Singapore, a pillar of the Singapore economy, and its major shareholders will be Singaporeans. But in terms of its culture and its outlook, it will be international, cosmopolitan, bringing together people from different countries and backgrounds.

Singapore too, will have to take a similar route as the skill demands of its economy increases. It too, will need to seek out the best and the brightest from far and wide, and eventually absorb and assimilate them. In this respect, ST's trajectory and that of the country which nurtured it will continue to run along parallel tracks. Indeed, the destinies of ST and Singapore will be as inextricably linked in the future as they have been since the inception of CIS thirty years ago.

Even as ST continues to be a major player in the domestic economy, it will also, through its regional and international thrusts, capitalise on its resources and that of Singapore Inc, and help transform the island-state into a fully globalised economy. As its mission statement states, ST aims to be "a technology-based multinational conglomerate, headquartered in Singapore, contributing to the development of Singapore and the region through successful enterprise." Similarly, Singapore too will continue to prosper by making itself useful to the region and the world, and becoming an especially productive node in the global economic system.

In this way, Singapore Technologies and Singapore, the part and the whole, will together march towards tomorrow.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CHRONOLOGY

1967

Chartered Industries of Singapore (CIS) is formed to support the Singapore Armed Forces by providing an indigenous capability for the production of small arms ammunition. Its first factory is a modest ammunition plant for 5.56mm calibre rounds.

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Singapore Shipbuilding and Engineering (SSE, now ST Shipbuilding) is formed to provide local capability to build and repair naval vessels.

The Singapore Mint production plant is established as a division of CIS. The Mint and CIS share common technical support facilities, including toolroom, foundry, quality assurance and assaying services.

1969

Singapore Electronic and Engineering (SEEE, now ST EASE) is formed to take over the buildings and equipment – and commercialise the operations – of the former weapons and electronic workshops of the British Naval Base.

SSE is awarded the contract to design and build four missile gun boats for Mindef in collaboration with Fr Lurssen Werft GmbH of Germany, with whom SSE has a technical cooperation agreement for the transfer of technology in patrol craft design and construction.

1970

SSE builds its first boat, a 25m ferry named "Kuala Batee", owned by the Sabang Free Port Development.

1971

Singapore Automotive Engineering (SAE, now known as ST Auto) is formed to do higher echelon maintenance and refurbishment of heavy military vehicles for Mindef.

1972

SSE completes building four missile gun boats for Mindef.

1973

Ordnance Development and Engineering (ODE) is formed to design, develop and produce medium and large calibre weapons.

Allied Ordnance of Singapore (AOS) is formed as a joint-venture with AB Bofors to manufacture Bofors's 40mm and 57mm guns.

Singapore Food Industries (SFI) is formed to supply food to SAF units.

SAFE (SAF Enterprises) is formed to provide retail services to SAF personnel.

1974

Sheng-Li Holding Co Pte Ltd is formed on 3 January to bring together all defence-related companies hitherto owned by Minister for Finance Incorporated (MOF Inc). Mindef remains the supervising ministry. The first Chairman of Sheng-Li is the late Ong Kah Kok (3 Jan '74 to 2 Jun '75). Sheng-Li's first Managing Director is Mr Bae Hong Pak (1 May '75 to 29 Nov '84).

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1975
Singapore Aerospace Maintenance Company (SAMCO, now ST Aerospace Engineering) is formed to take over the services hitherto provided for the RSAF by Lockheed Aircraft Services.

1977
SSE secures a large contract with a German company to build ten units of 1599 GRT container vessels.

Singapore Aero-Engine Overhaul Pte Ltd (SAEOL, now ST Aerospace Engines) is formed out of the SIA Engine Overhaul Base as a joint-venture between Sheng-Li and SIA. SAEOL does engine overhauls for SIA and the RSAF.

SAMAERO Co Pte Ltd is formed as a joint-venture between Société Nationale Industrielle Aérospatiale (SNIAS) of France and SAMCO to sell spare parts and tools for the Alouette III helicopters, and to do maintenance, repair and overhaul of SNIAS products and distribution of Écureuil helicopters.

1978
SSE hits a crisis point; the shipyard is on the verge of collapse – huge losses on the German container vessel project, and the banks want to call back on their loans.

Unicorn International (UI) is formed to serve as the international marketing arm for the ordnance businesses.

SAE, now ST Auto, launches its Autocentre.

1979
Sheng-Li's management, led by Kua Hong Pak, rescue SSE: they renegotiate the contract for the German container vessels, and the last four orders are cancelled then resold to other customers for better profit margins.

Mr Philip Yeo, Deputy Secretary of Mindef, becomes concurrently Executive Chairman of CIS.

1980
The then Minister for Defence, Mr Howe Yoon Chong, invites Mr JJ Gerzon (former CEO of Shell) to review Sheng-Li. One of his conclusions is that the companies within the group which engage in similar activities should be merged.

Philip Yeo begins diversification of the defence industries by spinning out service divisions within CIS – like logistics, construction and computer services – into separate companies.

Chartered Electronics Industries (CEI) is formed.

SEEL, SAE, and CIS join hands with Helicon and National Computer Board to create Singapore Computer Systems (SCS, now ST Computer Systems & Services).

1981
Following the Gerzon Report, Mindef approves the regrouping of companies within Sheng-Li into four main groups: (i) Ordnance: CIS, ODE, AOS, UI; (ii) Aerospace: SAMCO, SAEOL, SEEL; (iii) Marine: SSE; (iv) General Services: SAFE, SFI

Singapore Aircraft Industries (SAI, now ST Aero) is formed in December. SAMCO, SAEOL and SEEL are brought under SAI to consolidate Sheng-Li's aerospace companies. The move is in line with EDB's recommendation that Singapore strives to become the aerospace industry centre for the region.

SAL Leasing Pte Ltd (now ST Capital) is formed as a subsidiary of SAE, following the Gerzon Report which suggested that SAE should enter the leasing business for trucks, forklifts and other automotive equipment. To support the SAF's plan under the civil potential concept, SAL was to lease vehicles and equipment to the public which could then be mobilised in times of emergency.

1982
SEEL's Aviation Division is amalgamated with SAMCO's aircraft component repair business to form a new company, Singapore Aero-Components Overhaul (SACO, now ST Aerospace Systems).

CDC Construction and Development (now Singapore Technologies Construction) is incorporated as a subsidiary of CIS to design, manage and construct buildings on a turnkey basis for Mindef and Sheng-Li.

1983
Philip Yeo draws up plans for Singapore Technology Corporation (STC) to bring together the manufacturing and service capabilities of the ordnance-related companies under a single umbrella. STC becomes the holding company for CIS, SAE, ODE and UI. Sheng-Li continues as the holding company of STC, SSE, SAI, SAFE and SFI.

After successful completion of Changi Airport's Building Automation System, SEEL bids successfully to participate in the MRT project.

Chartered Firearms Industries unveils its Ultimax 100 assault weapon.

1986

Singapore Engineering Software (SES) is formed as a joint-venture between SEEL and the Swedish company, Ericsson Radio Systems AB, to build more engineering depth, particularly in the field of software development for real time command and control. In the longer term, the joint-venture enabled SEEL to tap into Ericsson's access to world markets.

Asian Aerospace Pte Ltd is formed as a joint-venture between SAI (now ST Aero) and Reeds Exhibition Co, the parent company of the organisers of the 1986 Asian Aerospace Exhibition in Changi Airport. Asian Aerospace's goal is to organise world-class exhibitions, in line with the promotion of Singapore as a regional aviation centre.

Mr Lim Ming Seong becomes Group MD of Sheng-Li (Dec '86 to Mar '92).

1987

BG Lee Hsien Loong, then Second Minister for Defence, gives a keynote address to the executives of Sheng-Li, announcing the Singapore Defence Industries (SDI) Charter. The Charter defines the role of the SDI, their relationship with Mindef and their strategic thrust. Also announced is the formation of an Executive Committee at Sheng-Li, with Philip Yeo as Chairman (he remains ExCo Chairman till July '92).

Sheng-Li, anticipating a slowdown in demand from the SAF in the 1990s, engages the Monitor Company of Boston, a consultancy associated with Professor Michael Porter from the Harvard Business School, to look into a strategy for diversification into commercial products and services aimed at the global market, based on the existing core competencies within the group.

Aero-Engine Manufacturing of Singapore Pte Ltd (AMS) is set up as a joint-venture between SAI and STC to manage a one per-cent partnership share programme led by Pratt & Whitney of America to manufacture PW4000 engine parts for the Boeing 747-400 and other aircraft such as the Boeing 767 and 777, the Airbus A300, and the McDonnell Douglas MD-11. This is Sheng-Li's first risk-sharing partnership programme involving international partners. AMS's mandate is to evaluate and invest in similar engineering products and programmes to bring manufacturing opportunities to the Sheng-Li group. (AMS eventually becomes part of ST's Precision Engineering arm.)

Chartered Semiconductor (CS) – later Chartered Semiconductor Manufacturing (CSM) – is formed, initially as a joint-venture with Sierra and National Semiconductor.

1988

Sheng-Li buys over Bofors' share in AOS.

Landor Associates is commissioned to create a unified corporate identity so as to improve the group's positioning in the international market.

1989

The group undergoes corporate restructuring and rationalisation. New corporate identity and sunburst logo are launched in April to bring together the diverse companies under a common logo and the single promotional name of "Singapore Technologies".

STIC (Singapore Technologies Industrial Corporation) is formed in April, grouping together the non-defence related businesses of Sheng-Li. Sheng-Li now has four main sectors – Ordnance, Aerospace, Marine and Industrial. STIC's primary mission is to:

(i) develop strong viable international engineering and industrial businesses in electronics, precision engineering and industrial services.
(ii) seek and nurture the international markets for its existing and new products and services.
(iii) acquire and develop relevant new technologies for its future business development and long term commercial viability as an international engineering group.
(iv) complement, support or extend the core activities of the Ordnance, Aerospace and Marine groups under ST.

CSM Fab 1 factory is completed in a record 14 months.

1990

Sheng-Li is officially renamed Singapore Technologies Holdings (STH) on 11 May.

ST Aviation Services Co (SASCO) is formed to do local commercial aircraft maintenance.

Singapore Technologies Ventures (STV) is formed as a fifth subsidiary of STH to acquire the startup companies of STIC. STV's role is to incubate, nurture and develop fledgling businesses in emerging technologies. The start-up companies are:

(i) AMS Precision Engineering
(ii) Chartered Electronics
(iii) Chartered Microwave (now CEI Systems & Engineering)
(iv) Chartered Semiconductor (now CSM)
(v) Evelca Investment
(vi) Origen International (since liquidated)
(vii) Vertex Management
(viii) Vertex Investment
(ix) Chartered Semiconductor Technologies (now TriTech Microelectronics)
(x) Advanced Materials Technologies
(xi) Gemplus Technologies Asia (since divested)

STIC joins forces with Jurong Environmental Engineering and Indonesia's Salim Group to build a giant industrial park in Batam.

BG Lee Hsien Loong, then Second Minister for Defence, announces that some component companies of STH will go public. ST Shipbuilding and ST Aero become the first ST companies to be listed.

1991

Mr JY Pillay becomes Chairman of STH (Dec '91 to Jun '94)

Public listing of ST E&E, ST Auto, ST Computer, and SAL Industrial Leasing (now ST Capital).

1992

CSM faces mounting financial problems. In the midst of its troubles and a worldwide downturn in the semiconductor market, CSM decides to invest in a new fab to increase capacity; Toshiba provides support by signing a memorandum of understanding expressing interest in investing in CSM.

Other troubled ventures in STV begin to turn around: AMS, Vertex and CEI Technologies.

Philip Yeo takes over as Chairman of STV in January '92; steps down as ExCo Chairman of STH in July '92, but remains Board member.

1993

CSM turns around – it is a watershed year. Management decides to go ahead with Fab 2.

An agreement is signed to begin the development of the Wuxi-Singapore Industrial Park.

Public listing of STIC.

Making the Future, an internal critique of ST structure and strategy, appears.

1994

STH, which was hitherto directly held by Minister for Finance Incorporated, is reorganised under Temasek Holdings.

Mr Lim Siong Guan becomes Chairman of STH (June '94 till April '95). Philip Yeo resigns as Chairman of STV in April '94, and Lim Siong Guan takes over.

ST Telemedia is formed in November to focus on media and telecommunications investments and operations in the Asia-Pacific region. Strategy is to leverage on the convergence of technologies to entrench Singapore as the telemedia hub of the region and beyond.

1995

STV is restructured into ST Pte Ltd (STPL), the operational headquarters of ST, to provide support and strategic direction to the 14 SBAs (Strategic Business Areas), which are organised into five core competencies. Lim Siong Guan steps down as Chairman of STH in February '95 and becomes Deputy Chairman.

Dr Yeo Ning Hong is appointed Chairman of STPL in February, and later becomes Executive Chairman in April. Ms Ho Ching becomes MD of STPL, together with Mr Wong Kok Siew.

CSM decides to proceed with the construction of Fab 3.

Wong Kok Siew resigns as MD of STPL and as President of STIC to join Nomura in November. Wong continues to serve as non-Executive Chairman of STIC.

1996

Lim Siong Guan resigns as Deputy Chairman in April

ST establishes a property arm with the acquisition of Pidemco, a large government-linked property development company, from Temasek Holdings.

ST acquires Micropolis Inc, a maker of hard disk drives.

ST acquires 80 percent of Dornier Medizintechnik GmbH.

Framework agreement for Asian Consortium Cooperation is signed in February between Aviation Industries of China and ST to jointly research, design, develop and manufacture a family of aircraft in the 100-seater market segment.

1997

Yeo Ning Hong steps down as Executive Chairman of STPL to assume a full-time role as Chairman of the Port of Singapore Authority. Ho Ching becomes President and CEO of STPL. Mr Teo Ming Kian, Perm Sec, Ministry of Communication, becomes STPL's non-Executive Chairman.

ST Aero makes an impressive turnaround, posting a $28 million profit after a $48 million loss sustained in 1995.

Colophon

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