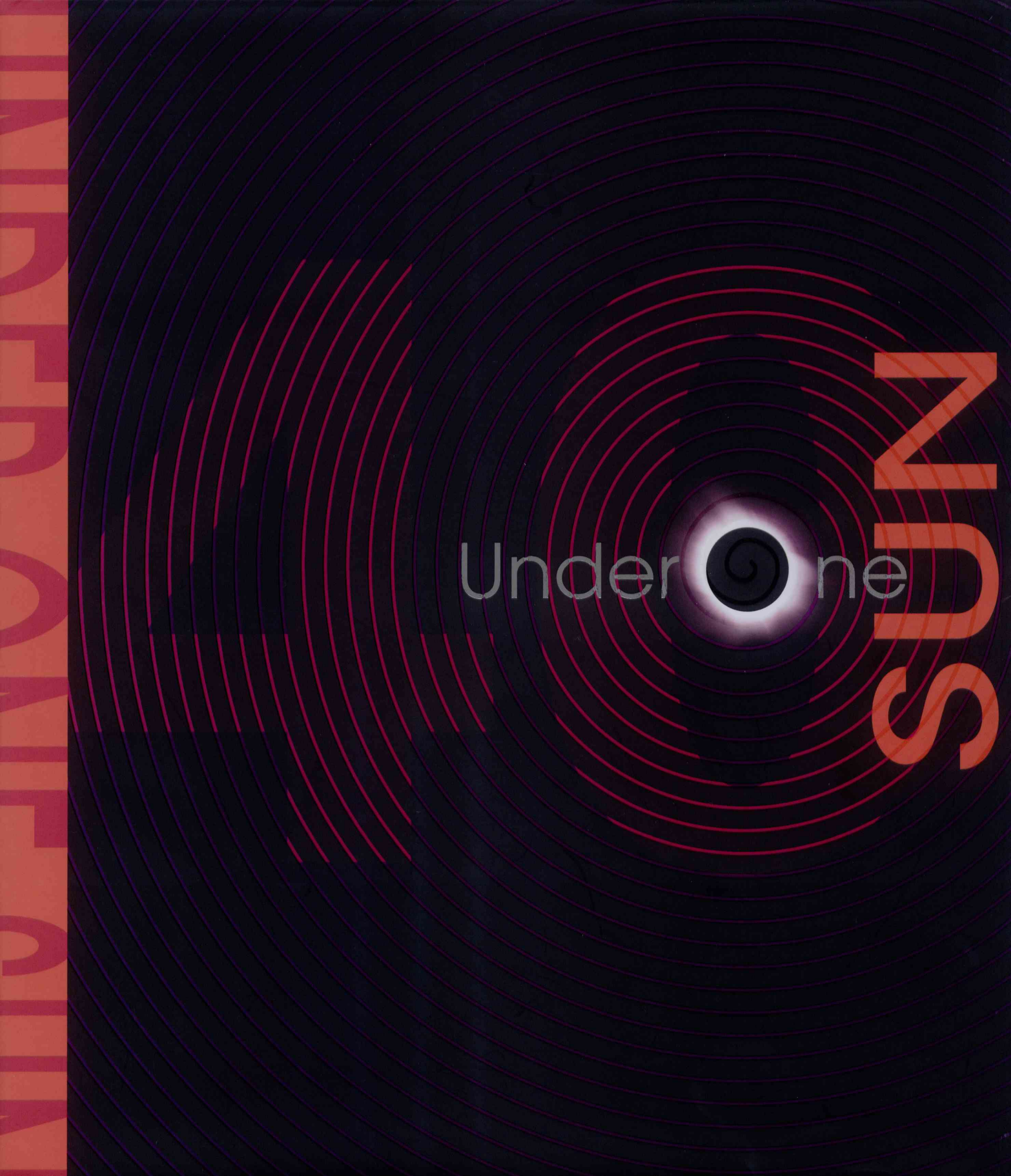

Under one
SUN

Under One Sun

ST Engineering's story began 40 years ago in a reclaimed swamp in Jurong. Its humble beginning, a production line for 5.56mm ammunition, was part of a nationwide effort to help a newly independent Singapore survive.

This first outfit, Chartered Industries of Singapore, was quickly joined by companies in the aerospace, electronics, land systems and marine sectors to form a credible defence industry for Singapore. Banding together to form ST Engineering in 1997, the Group is today a formidable player in both commercial and military sectors.

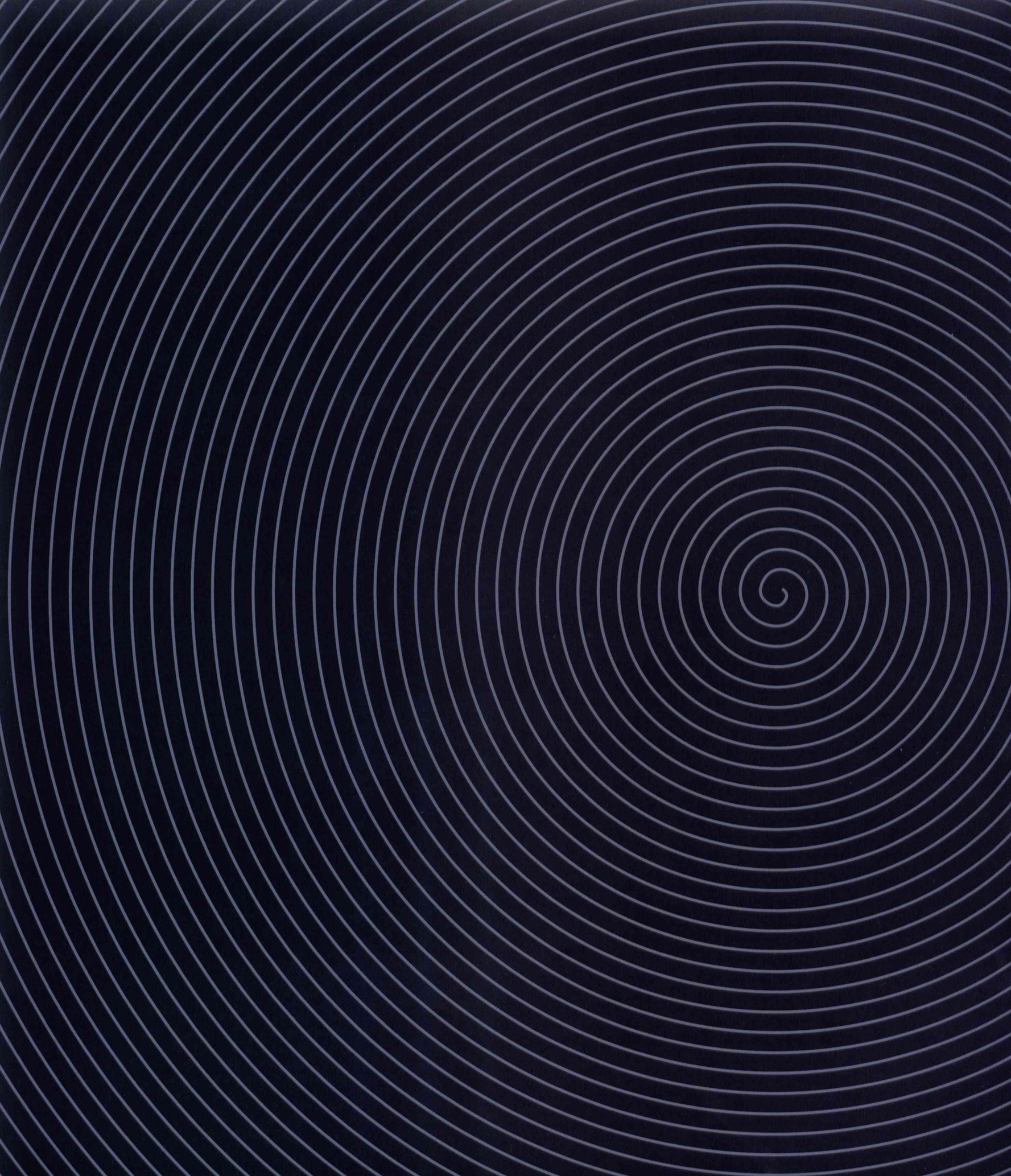
This book is an account of those 40 years and a snapshot of where ST Engineering stands today and where it is headed in the future. It is also a tribute to the men and women who built a company on the bedrock of integrity and excellence.

Celebrates 40 years of Engineering Excellence

We dedicate this book to
our customers and partners for their trust,
our founding fathers for their vision,
our shareholders for their faith,
our pioneers and staff for their commitment;

and to the people of Singapore,
the reason ST Engineering was born.


KONECRANES



Under one SUN

ST Engineering


B 767 BW DRIVE KEY

Contents

Foreword

ST Engineering is what it is today because we dared to dream, to reach out beyond our borders and establish launchpads around the world.

The foresight, perseverance and commitment of our personnel have enabled the transformation from a local company into a premier Singapore multinational corporation in just four decades. We now have a culture that sparks entrepreneurship and ignites creativity.

Those of you familiar with our history would remember that we started in 1967 as Chartered Industries of Singapore, which produced ordnance such as 5.56mm ammunition for the Singapore Armed Forces. We have since evolved into a global enterprise engaging in defence and commercial businesses.

We realised that our strength was our ability to synergise the various capabilities among the core businesses to derive a unique selling proposition relevant to the marketplace. Take electronics, for example. It's an overlay throughout the land systems, marine and aerospace sectors. Each business area augments the others.

As ST Engineering grew, we knew that it was a company capable of exporting its services and products to the world. It was also evident that many of our capabilities could be put to good use in the commercial area.

The groundwork for going global began when the Group was restructured in 1997 to form what is known today as ST Engineering. The revamp made the Group's leadership more aware of how capabilities and technologies in the different sectors complemented each other, giving the Group a unique selling proposition – integrated solutions.

We now offer sophisticated systems, services and solutions in the aerospace, electronics, land systems and marine sectors. One of our best-known products to the public is the fever screening system that was used during the Severe Acute Respiratory Syndrome (SARS) crisis in 2003. It was an outstanding example of quick response and good leverage on defence technology for commercial application.

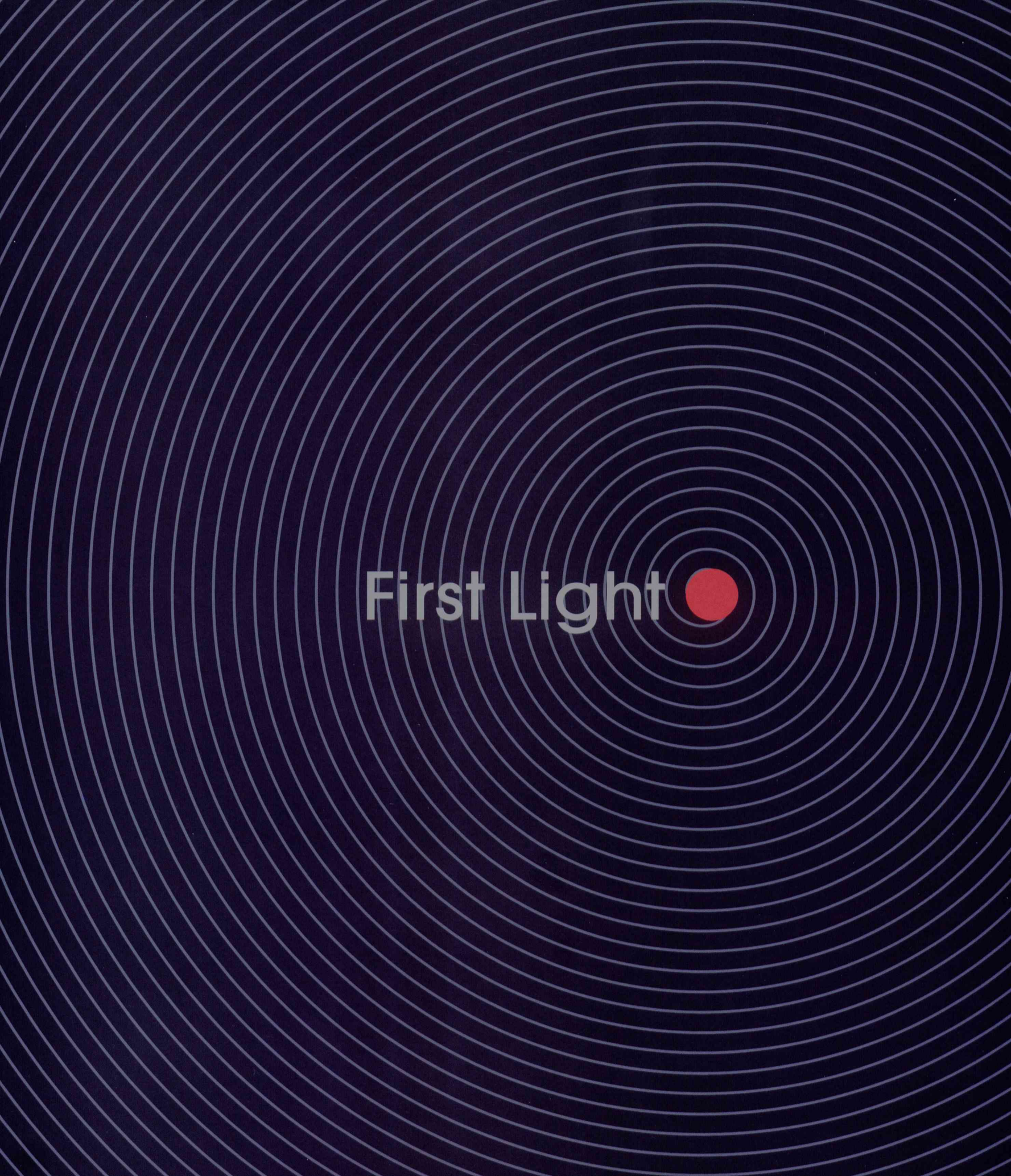
Most significantly, people have been our driving force. We could not have made any headway without their dedication to fulfilling the vision by piecing together a dynamic global blueprint for the Group.

We will continue to stay focused. We won't do everything under the sun. ST Engineering is essentially still a defence group that has built a very strong commercial business riding on many of our core defence skills. The sun will guide our paths.

We are ready to accomplish further. Happy 40th anniversary!

Peter Seah

Chairman
Singapore Technologies Engineering
September 2007

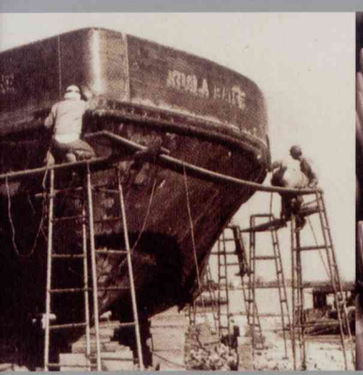

First Light

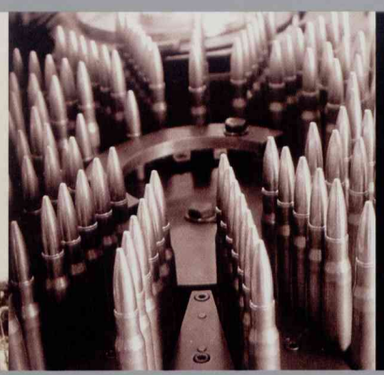
SINGAPORE Technologies Engineering Ltd (ST Engineering) is an international corporation that employs over 18,000 people all over the world, with products, systems and services reaching every continent.

In the air, many jetliners and freighters are maintained or converted by ST Engineering. On the high seas, ships maintained, modified and built by ST Engineering plough through the waves to deliver cargo across the world.

On the ground, specialty vehicles built by ST Engineering transport goods, deliver emergency services and support infrastructure projects. And connecting everything and everyone are the electronic and Information Communications Technologies (ICT) systems of ST Engineering that automate massive building complexes and subway systems, manage real-time emergency services and let people talk to each other across the globe.

In Singapore, ST Engineering is also tied closely to the nation's defence. It gives the Singapore Armed Forces (SAF) support in maintenance and logistics





CHAPTER ONE

(L to R)
1. Boatbuilding in the early days of Benoi Yard.
2. CIS's first product – the 5.56mm round.
3. Working on electronics components.
4. Singapore Aerospace Maintenance Company (SAMCO) began operations as a maintenance base for the Singapore Air Force.

as well as creates or integrates new products to provide the SAF with new capabilities. For the rest of the world, ST Engineering provides the systems and expertise for homeland security solutions.

ST Engineering has grown – from a diverse collection of companies created to support the SAF – into an integrated global company. Its position in the world today is testament to the hard work, dedication, daring and ingenuity of its people over the last four decades. This is their story.

A New Kind of Bullet

The ST Engineering story began with the basic need for bullets and the company, Chartered Industries of Singapore (CIS), set up to make those bullets. This first product was the 5.56mm ball round for the M16 rifle, a new size of ammunition for a new rifle made by Colt of the United States. Until then, no other weapon had used this calibre of ammunition.


TIONG BAHRU CONSTITUENCY CELEBRATES
NATIONAL DAY

Self Defence

The National Service Act was passed in 1967, requiring male citizens, on reaching the age of 18, to perform up to two and a half years of service to the nation. This usually meant the army. Today, National Servicemen (NSmen) serve in the SAF, the Singapore Police Force and the Singapore Civil Defence Force in a wide variety of occupations. Their mission, however, is the same – to protect Singapore's sovereignty and people.

(Above, L to R)

1. Dr Goh Keng Swee (right) chairs a meeting with Pang Tee Pow, Permanent Secretary (Defence).

2. Dr Goh, with Sir Laurence Hartnett (behind Dr Goh, to his right), visits the cartridge making line. Sir Laurence did the initial planning for the ammunition factory and later recommended the formation of Ordnance Development and Engineering (ODE).

(Opposite)

The SAF Infantry marching proudly past residents of Tiong Bahru during the National Day Parade in 1973.

The 5.56mm calibre Colt M16 had been chosen as the standard assault rifle of the newly-formed SAF and large quantities of 5.56mm rounds were needed.

Lieutenant-General (Retired) Winston Choo, Singapore's first Chief Defence Force, and later on, Chairman of CIS, said of the M16: "All other assault rifles used the 7.62mm round or an AK-47 type round. The new M16 had a higher muzzle velocity and this made a smaller round possible."

Given the smaller stature of the Singaporean soldier at the time, a shorter and lighter weapon made sense. A smaller round would also mean each soldier could carry more.

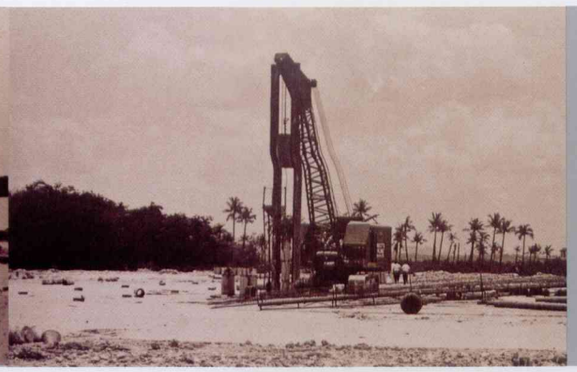
Born of an Urgent Need

Singapore gained independence on 9 August 1965. Dr Goh Keng Swee, Minister for the Interior and Defence, was tasked to develop an effective army for Singapore. In 1965, there were only two battalions in Singapore. What made the situation look even worse was the British announcement of their withdrawal from their bases east of the Suez by 1971. Singapore's Israeli military advisors worked out a plan to build up the Singapore Armed Forces through military conscription. They also advised the Singapore Government to build its own ammunition factory.

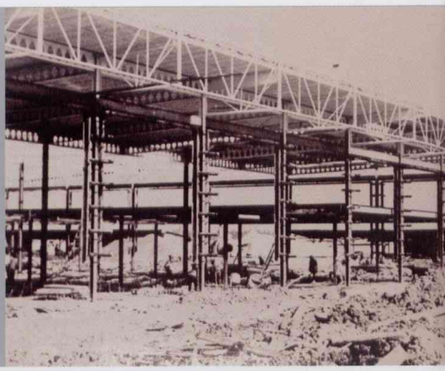
Innovation from the Start

Dr Goh weighed the options. Importing all the ammunition would have been expensive and would have made Singapore more vulnerable to disruptions in the supply chain.

Sir Laurence Hartnett, Australia's Quartermaster-General in World War Two, was appointed to head the project. He also found a new way to make ammunition. He used brass rods to make the cartridge cups instead of brass sheets as was the practice then. As it turned out, the new method resulted in better cartridge cups that were also cheaper to produce. He also introduced the "cold room" idea to making ammunition in order to protect the gunpowder from the dampening effects of Singapore's humidity.



(L to R)
1. Jurong was a swamp before development; 69 acres were leased for 99 years.
2. The hills had to be levelled to fill the swamp.
3. Structural elements for the CIS plant were then erected.



Setting Up CIS

Tham Mow Siang, an Administrative Assistant in the Civil Service at the time, set up the new company while Sir Laurence acquired 69 acres of land in Jurong for the ammunition factory.

While the factory was being built, Mr Tham registered the company, Chartered Industries of Singapore (CIS), the first government-linked company (GLC) in Singapore. The company's first office was at Cathay Building and the first modest plant producing the 5.56mm ball rounds was located at Jalan Boon Lay, the site of ST Kinetics today.

Mr Tham became CIS's first Company Secretary, with Whang Tar Liang its first Chairman. Mr Whang was the Chairman of the Singapore Manufacturers' Association at the time. George Bogaars, then Permanent Secretary of the Ministry of the Interior and Defence, became one of the company directors.

CIS was officially opened on 27 April 1968.

Uncompromising Quality

Under the zinc roof of their new factory in the former swamp of Jurong, CIS's employees got down to the job of making quality 5.56mm ball rounds. To test the ammunition, CIS eventually built tiny open ranges with baffles to prevent stray shots from leaving the area. To test the ammunition over longer ranges, CIS used the SAF's ranges and live-firing areas, and would later also go overseas for testing.

Professor Lui Pao Chuen, now Chief Defence Scientist, joined the Defence Ministry (MINDEF) in 1966. He noted that for the first 5.56mm ball rounds, there were no US military specifications available yet. So Professor Lui and his team had to write their own.

"The tolerances were tight – you tighten them when you have any doubts!" said Professor Lui. "CIS almost killed themselves trying to meet the specifications."

The risk was also very real to the MINDEF testing team. When the first batch of bullets was completed, Professor Lui went down to test-fire them. He loaded five rounds and began to fire. The fourth round exploded. Bits of brass went straight into his arm – there had been too much propellant.

Adjustments were quickly made and by the time experts from Colt came in, CIS had perfected the manufacturing process.

(Opposite)
The Jalan Boon Lay site, completed. CIS was incorporated on 27 January 1967 and officially opened on 27 April 1968.

The Role of CIS in Nation-building

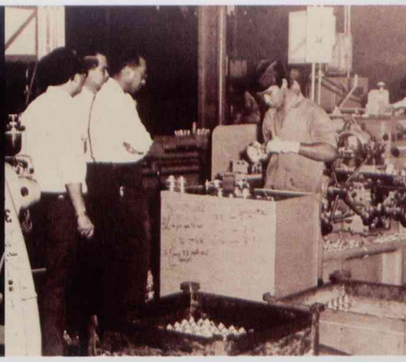
Dr Goh Keng Swee said in *Towards Tomorrow: The Singapore Technologies Story* (1997) that CIS rose to the challenge and fulfilled its mission despite his initial doubts about having a munitions factory. More than that, it helped greatly in Singapore's development as an industrialised country.

"CIS, when it started, formed the core of the government's industrial effort," said Dr Goh in the Singapore Technologies Pte Ltd (STPL) interview. "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."

CIS made a wide range of ammunition, from 5.56mm to 155mm howitzer shells.

(L to R)
1. Ammunition production in full swing.
2. An engineer testing the world's lightest machine gun, the Ultimax 100.
3. Dr Goh inspecting the ammunition production line in the late 1960s.



"When the Colt marketing team test-fired a box of cartridges, they declared the CIS product 'match grade'," said Professor Lui. "These are competition rounds that are handmade and filled by hand. The precision of the CIS-made rounds was so high that Colt bought CIS ammunition for their M16 demonstrations around the world. So out of our own ignorance, we pressed CIS to create a really great product!"

"The locally-made munitions were good products – good enough for us to look into exporting," General Choo said. He added that no subsidy was given to CIS. It had to compete with other countries to produce better ammunition at lower cost.

Making the M16

Making what was probably one of the best 5.56mm cartridges in the world was not enough. Colt Industries, the manufacturer and owner of the M16, had let CIS handle the assembly of their famous rifle. As CIS grew in capability, the company began to handle the manufacture of parts and subassemblies of the M16, but only for the SAF's use. Throughout this period, CIS not only learnt how to build excellent rifles and grenade launchers, but also learnt how to design and manufacture their own rifle.

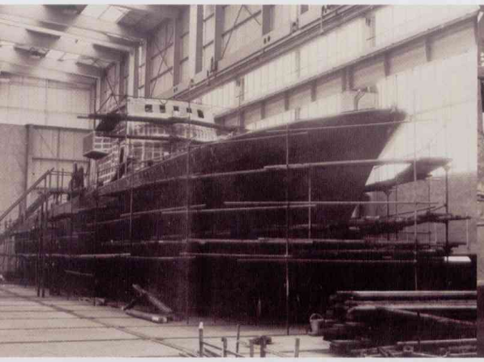
The defence of Singapore, however, would depend not just on land forces. Dr Goh's second task was to set up a shipyard that could build naval craft.

Ships for an Island Nation

Alone on the banks of the Benoi River in the desolate western end of Singapore, a small group of 19 men gathered in 1968. They had few tools, no special equipment, and for shelter, only a zinc-roofed shed. They did not even have a reliable supply of water.

They were expected to build boats. Not just any boats, but the boats of a new navy tasked to defend the vital sea lanes of Singapore. Compared to its sister company, CIS, this little yard did not have the benefit of ready facilities and sophisticated production line machinery. But Dr Goh, the man who had asked for the creation of this tiny company of brave boatbuilders, saw a very clear and bright future for it.


SEA HAWK
P 80



(L to R)
1. A missile gunboat under construction at Benoi Yard.
2. Finance Minister Hon Sui Sen (second from left) visiting SSE.
3. Missile gunboat in the early 1970s.

(Opposite)
Four of the six missile gunboats built locally by SSE. This picture was taken after they were upgraded with Harpoon missiles.

Commercial Potential

Blessed also with a deep harbour and a long history of ship support and repair in the naval and commercial sectors, Singapore had both location and legacy.

Of course, Dr Goh's priority was to develop a way for Singapore to be self-reliant in the protection of the island state's sea lanes. A shipbuilding concern could also diversify in a way an ordnance factory could not. The region needed small vessels like barges, coastal freighters, tugboats and, of course, gunboats.

Getting Up to Speed

Dr Goh gathered a group of local entrepreneurs and persuaded them to start a shipyard. Whang Tar Liang (who was also the first Chairman of CIS), Tan Soen Swan and Baey Lian Peck responded quickly.

In May 1968, they set up Singapore Shipbuilding and Engineering Pte Ltd (SSE) as a private venture with the Singapore Government holding a minority stake. The new company set up shop at the mouth of the Benoi River in Jurong Industrial Estate.

A Slow Start

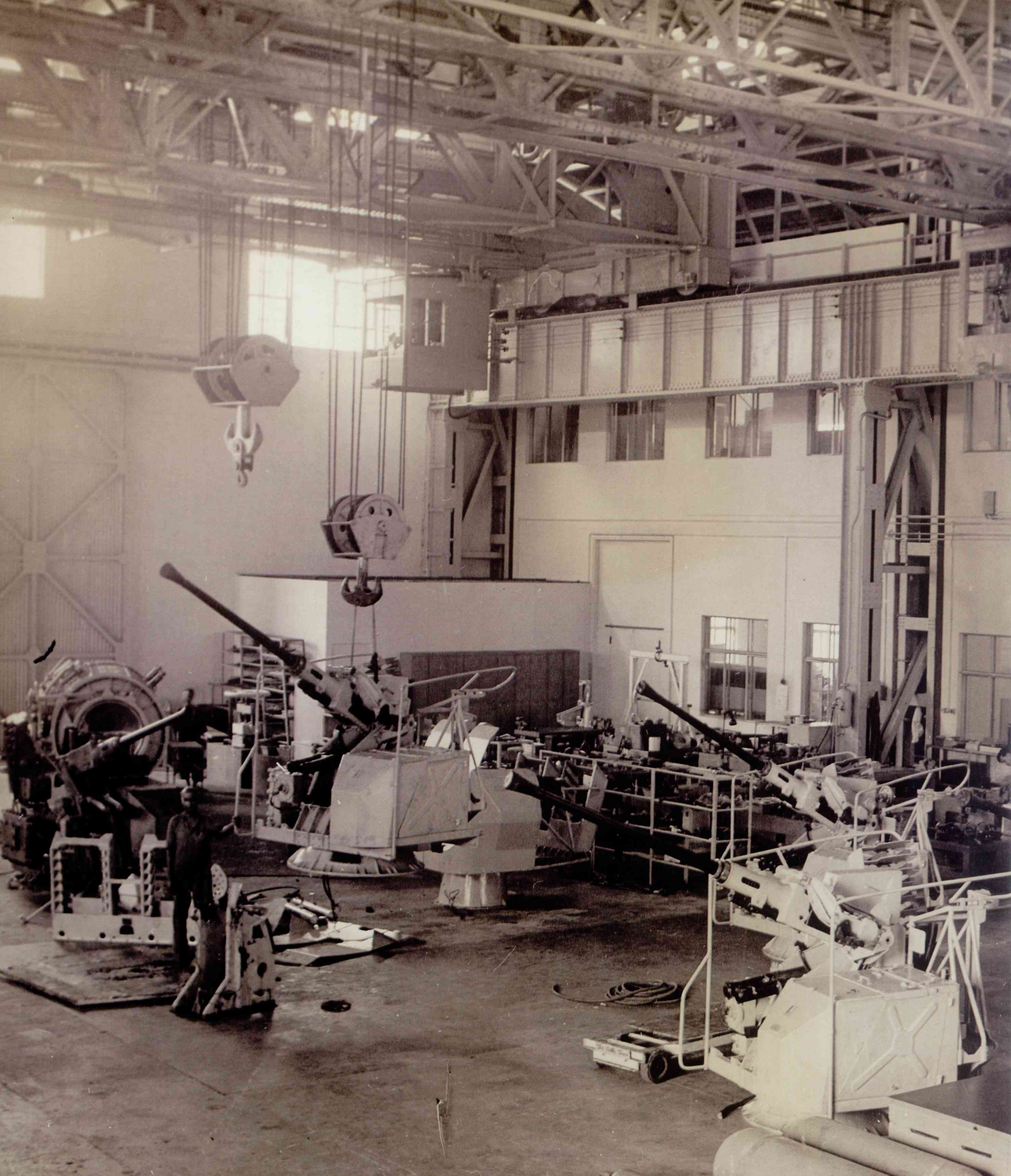
Business was slow for the first two years. Most yards were in the Kallang River area, on the other side of the island, so it may have been a case of "out of sight, out of mind".

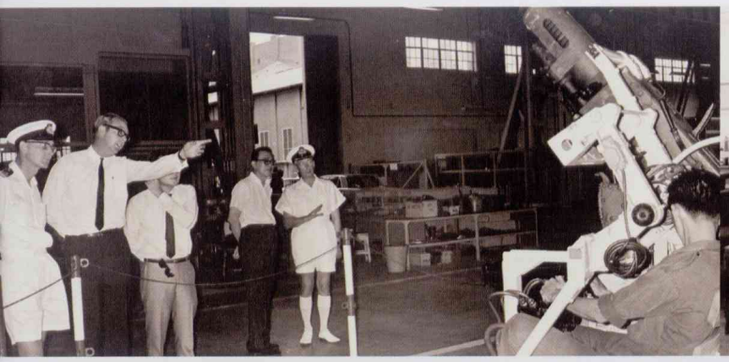
The yard survived by building inshore vessels for private owners. But its primary reason for existence – the development of an indigenous capability to build naval vessels – would soon give the yard a boost that no other local shipyard could boast of.

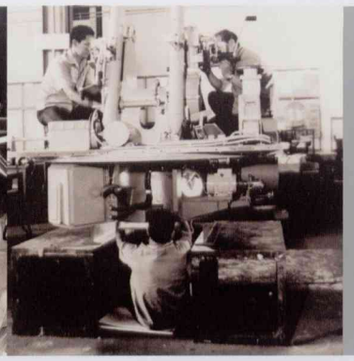
The Missile Gunboats

The year after the yard was established, the Maritime Command, predecessor of the Republic of Singapore Navy (RSN), signed a technical cooperation agreement with Fr Lurssen Werft of West Germany. Lurssen was a world leader in the design and building of missile armed high speed naval strike craft.

Six missile gunboats (MGBs) were ordered. The first two would be built by Lurssen at their Vegesack yard. The remaining four were to be built in Singapore,







(L to R)
1. A VIP visit to the naval gun workshop at Sembawang.
2. Technicians working on a naval gun.
3. SEEL also had facilities to repair electronic equipment.

(Opposite)
40mm Bofors naval guns being serviced at SEEL's facility in Sembawang.

with Lurssen working with SSE to produce the vessels and at the same time, transferring the technology and knowhow for modern marine technology – especially in the area of naval strike craft construction.

While waiting for the first two craft to be built at Vegesack, SSE began preparing itself for the major task of building the MGBs. These were 45m vessels and SSE, up to that point, had not built anything approaching that size.

The yard now had the ability to build the boats, but weapon systems were quite another thing. These were installed by MINDEF's Systems Integration Management Team. The four vessels – *RSS Sea Dragon*, *Sea Hawk*, *Sea Tiger* and *Sea Scorpion* – were delivered in 1973.

But before that, another interesting opportunity presented itself to Dr Goh, offering ready facilities and trained personnel.

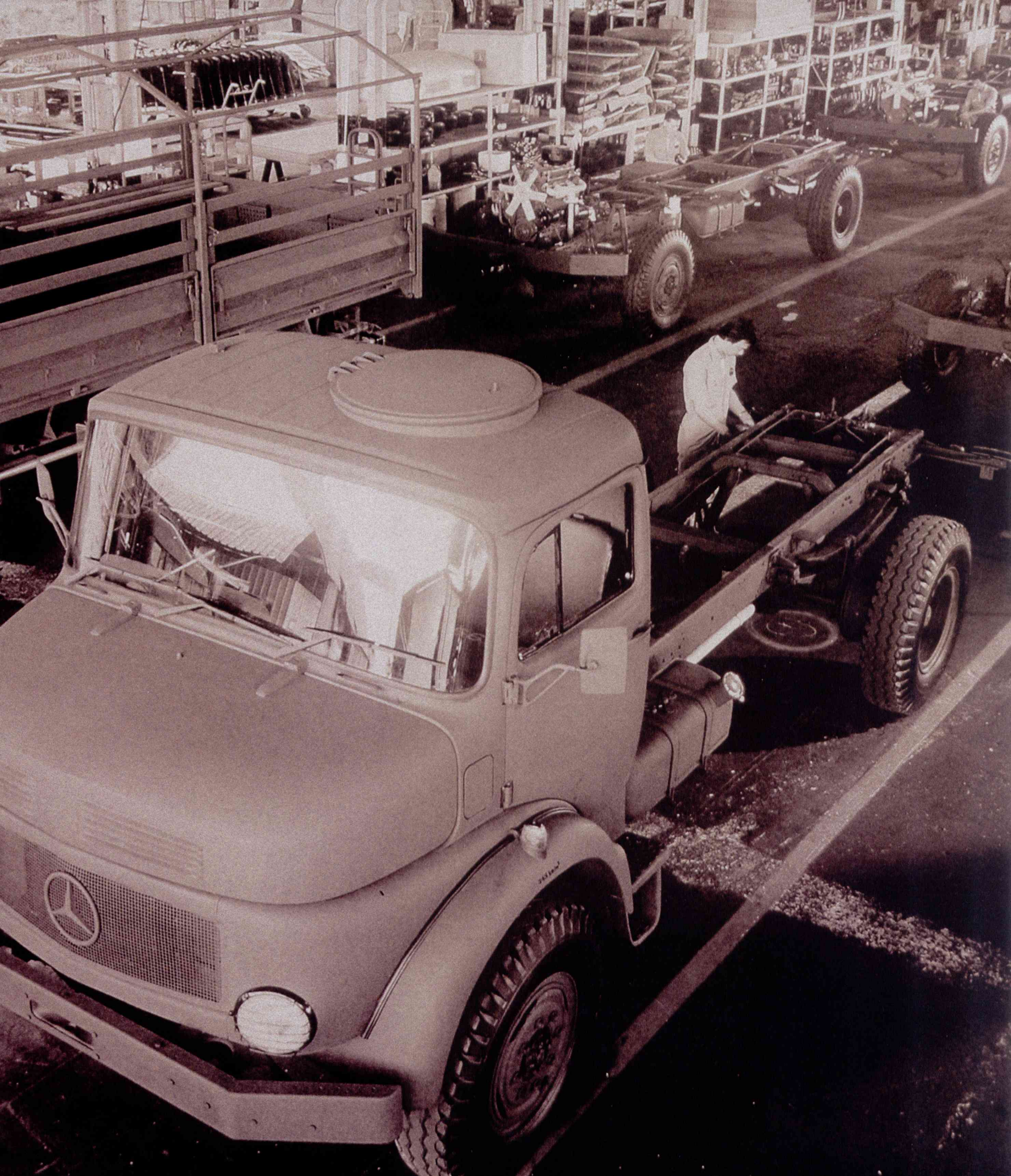
Riding the Spectrum

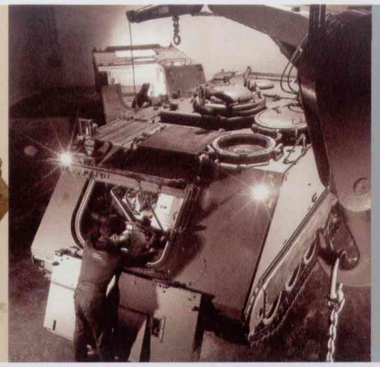
On the modern battlefield, the ability to connect and coordinate fighting systems and units in an instant is a matter of life and death. The force that has command of this invisible front has a distinct edge over one that does not.

The third sister company of CIS and SSE to be born was SEEL – Singapore Electronic and Engineering Limited. The British Royal Navy was withdrawing, but it was leaving behind many fixed assets the new island state would find valuable. Swan Hunter had acquired Her Majesty's Sembawang Dockyards, but found a part of it – the Royal Navy's old weapons and electronic workshops – not viable for their commercial operations.

These workshops were fully operational and staffed by experts in weapons maintenance, seconded civilians and Royal Navy personnel who had serviced and maintained the Royal Navy's vessels. It would have been a waste to let all that specialist talent and equipment go.

SEEL was formed in 1969 to take over the facilities and personnel of these workshops. The new managing agent for the workshops would be Philips Australia, which had the necessary knowledge and experience to handle the type of work SEEL was created to do.





(L to R)

1. The amphibious V200 roars ashore.
2. A technician conducting quality checks on the M113 Armoured Personnel Carrier.
3. M113s lined up in a workshop for modification.

(Opposite)
SAF's 3-ton trucks being re-assembled after a life extension programme.

G. Selvaraj, Manager, Defence Business, recalled those early days at SEEL: "I loved the work environment and the people around me. We worked in a long hangar. There were offices on both sides of the building. There was a section that repaired guns like the Bofors, a radio section and a calibration workshop. I was part of the general engineering section which had around 60 people.

"Our hangars were old British hangars. They were about three storeys high, with cranes and a high bay. They were very comfortable too. The offices were air-conditioned – a real luxury in those days! But in the hangars where the mechanical work was carried out, the men had to wear overalls – it was hot and greasy work."

But as with CIS and SSE, the SAF's business was not guaranteed. It was up to SEEL to make itself relevant to the SAF, just like any other customer it anticipated.

A Mobile Fighting Force

As the SAF grew, so did its vehicle fleet. With the greater need to train soldiers for combat roles, the SAF decided to outsource its vehicle maintenance work. In 1971, Singapore Automotive Engineering (SAE) was set up and found a permanent home in the SAF's vehicle maintenance base at Ayer Rajah.

SAE's first job was to maintain the fleet of V200 Armoured Personnel Carriers. This was quickly followed, in 1972, by the repair and overhaul of the fleet of Bedford trucks left behind by the British.

"When SAE started out in 1971, we were 'grease monkeys' doing preventive maintenance jobs on the newly acquired V200, which was specifically designed and manufactured to the SAF requirements," quipped Wu Tzu Chien, now President of Special Projects at ST Engineering. "Thereafter, we did many repair and overhaul jobs as well as Limited Depot Overhaul (LDO programmes) on SAF fleets of vehicles, thus giving the vehicles another round of service life.

"During the early years, the SAF bought lots of other armies' surplus tanks, military trucks and Land Rovers. SAE refurbished and modified them and gave them a new lease of life.

"Throughout the organisation, everyone was doing maintenance. However, everyone was itching

Of Tracks and Wheels

SAE has changed its name twice. It first became Singapore Technologies Automotive in 1995 before becoming Singapore Technologies Kinetics after acquiring CIS in 2000.

As ST Kinetics, it now has more products in its stable including the Infantry Fighting Vehicle more popularly known as the Bionix. Then there is the Spider Light Strike Vehicle, a buggy-like off-road wheeled vehicle. The Bronco is an articulated all-terrain tracked vehicle that also has non-military uses, like rescue and recovery operations. ST Kinetics now extends its product range to also include weapons and munitions systems.

ST Kinetics has come a long way from servicing B-fleet vehicles and combat vehicles like the V200, AMX-13 and M113, to actually designing and building its own. Yet it still does maintenance and crash repairs for ordinary cars through its STAR Automotive Centres!

An upgraded AMX-13, renamed the AMX-13 SM1, charges ahead in a cloud of dust.

(L to R)
1. SAMCO technicians servicing a Hawker Hunter fighter aircraft.
2. Aerial view of SAMCO at its first operations premises – Seletar Air Base.

to do more – to make our own products and to show the world and more importantly our customer that we had substantial capability and knowledge to meet the challenge if given the opportunity."

SAE would eventually get its chance, thanks to a second-hand light tank that had to be refurbished and upgraded to meet the then future requirements of the SAF.

Until then, there was another vital dimension Singapore's defence forces had to protect – our skies.

Close Air Support

Many older Singaporeans remember with fondness the Hawker Hunter with its sleek and handsome lines, swept-back wings and charismatic voice, aptly named the Blue Note. When Singapore-marked Hunters first took to the air, these combat aircraft of the new Singapore Air Defence Command (SADC) were a reassuring sight for those who had survived the horrors of the Japanese Occupation.

What most people did not see, however, was the work involved in keeping these aircraft flying – and the tiny company set up to help our pilots do their job.

Military but Commercial

The SADC had depended on Lockheed Aircraft Services not just for the support of the BAC Strikemasters and Hawker Hunters, but also to assemble and service the SADC's first McDonnell Douglas A-4 Skyhawks. But with the US pullout from Vietnam, Lockheed, which had also supported US forces, found its revenue greatly reduced. It could not sustain its business in Singapore.

A group of logistics officers from MINDEF believed it would be in the best interests of Singapore to develop its own capability in this area. However, they also recognised the usefulness of outsourced service providers. They persuaded MINDEF to set up a local company to do this. MINDEF also saw the potential in the regional aerospace industry – something only a commercial company could take advantage of.

As one of the gateways to Asia, Singapore had the potential to become a major air transport hub. It was already a very important sea port. Air communications would have a significant role to play in Singapore's development.


Black Knights

(L to R)
1. The A-4C was refurbished to the A4S-1 Skyhawk by SAMCO.
2. A C-130 stripped of paint for inspection.

(Opposite)
A-4s galore in the SAMCO hangar.

SAMCO is Born

Singapore Aerospace Maintenance Company (SAMCO) was formed in 1975 to take over this two-pronged role. At the time, there was a serious shortage of highly skilled labour in Singapore, especially in an emerging industry like aerospace, so SAMCO also took under its wing some of the technicians and engineers from Lockheed Aircraft Services.

Patrick Wong Yeok Yeok, former Head of Air Engineering Department (AED) in the SADC, was given $3 million in capital to start the company and he quickly acquired hangar facilities. SAMCO immediately got to work, taking over from where Lockheed left off.

Meanwhile, Singapore Airlines (SIA) had also set up its own engine overhaul facility. The Singapore Airlines Engine Overhaul Base started in 1974 to take care of its jetliner engines.

In 1977, Singapore Aero Engine Overhaul Limited (SAEOL) was formed – a joint venture between Sheng-Li Holding Company Private Limited (Sheng-Li), the government's holding company, and SIA, to overhaul the aircraft engines of SIA and the Republic of Singapore Air Force (RSAF).

Thomas Jeyaseelan of ST Aerospace's Engineering & Development Centre (EDC) joined in 1980. He remembered the early days vividly.

"We had our operating headquarters in West Camp, Seletar. It was small, with a total staff strength of 15, led by an assistant manager. The maintenance activity in the company – for the RSAF's fleet and the US Navy and Marines KC-130F/R aircraft – was supported by an in-house hydraulics shop, tyre and fuel cells repair bay, engine shop, battery shop and paint shop. The company also had a well-equipped sheet metal shop mainly producing aircraft repair parts. In all, there could have been less than 800 staff."

Start Small, Think Big

All four business divisions of ST Engineering today – ST Aerospace, ST Electronics, ST Kinetics and ST Marine – had very humble beginnings.

Subject to market discipline and under obligation to commit their initially meagre resources to military work first, it might have seemed to an informed outsider that these little companies had no way to grow. Yet grow they did – if not without pain.

(L to R)

1. Coastal patrol craft, designed and built locally, started service in the navy, but today serve in the Police Coast Guard.

2. The first cargo container vessel built for Hellenic Lines, Greece, was completed two months ahead of schedule.

Rough Waters

As Southeast Asian economies grew, there was ample work for local yards and SSE was no exception, especially after it won the missile gunboat contract.

But the oil crisis of 1974 changed the outlook, even though the yard's reputation had earned it several important orders. The RSN had ordered a few logistics vessels, but budget priority was now with the new air force and the RSN had no other work for SSE. The yard began a four-year decline that took it to the verge of financial collapse. There were also ongoing problems between management and labour.

Then SSE made a mistake in 1978, when it badly underbid a contract for a series of 10 cargo container vessels for a consortium of European owners. The banks considered calling their loans.

Sheng-Li had been set up in 1974 as a holding company for all defence-related companies. Kua Hong Pak, who had been handpicked by Dr Goh to be the Managing Director of Sheng-Li, was given the concurrent appointment of Managing Director of SSE in 1979. Pooling funds from the other companies in the group, Sheng-Li injected fresh capital into SSE. A team from the RSN followed Mr Kua into SSE, and together they turned around the ailing yard in a single year.

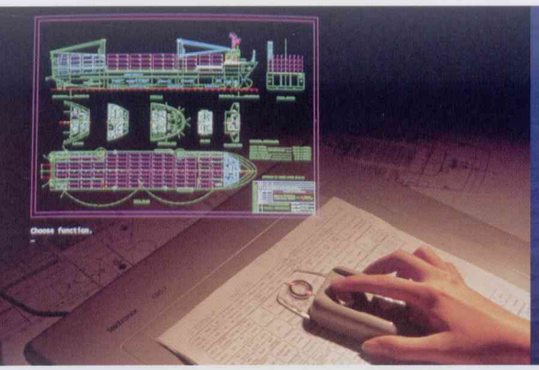
Setting a New Course

SSE began to move more aggressively into the commercial market, offering its own designs. Mr Kua built a pool of top-grade engineers for SSE. He also introduced a variable bonus scheme to raise productivity and improve employee commitment.

By 1981, the yard was clearly back on an even keel, winning a major contract for three 120m cargo container vessels for Hellenic Lines, a Greek company. It was one of the largest contracts for a local yard then. SSE scored another significant achievement when it delivered the vessels ahead of schedule.

Taking It to the Next Level

When Philip Yeo took over as Chairman in 1984, his aim was to take SSE global. To break away from the pack, SSE acquired a Computer-Aided Design and



(Above, L to R)

1. SSE was the first yard in Asia to acquire the CAD/CAM system.
2. The Victory Class missile corvettes.
3. The 400 TEU RoRo/LoLo container vessel for Tropical Shipping and Construction was completely designed and built by SSE.

Computer-Aided Manufacturing system (CAD/CAM). The first Asian yard to harness the power of this system, SSE gave its team of top-grade engineers a "force multiplier".

The RSN awarded another contract to SSE and its technology partner, Lurssen, to build six missile corvettes. These 62m vessels, hard-hitting and fast-moving, stood at the apex of the RSN's fleet at the time. One would be built in Germany and the other five in Singapore.

The second half of the 1980s saw SSE extending its high-tech edge to build innovative vessels like the Tiger 40 Hovercraft, the first of its kind to be built in Singapore.

World Class

In 1991, the yard beat stiff competition from US, European and Japanese yards to win a contract to build two 400 TEU RoRo/LoLo vessels for the US-based Tropical Shipping and Construction. These vessels, the *Tropic Tide* and *Tropic Sun*, were designed completely by SSE's naval architects. When they were delivered in 1993, the owner praised the vessels as "unique in the world ... moulded from imagination to reality by exceptionally creative and capable talents of the SSE team and their exceptional computer-design facility".

SSE's capabilities took another step forward when the RSN gave it the contract to do outfitting and maintenance work on its mine counter-measure vessels which involved glass-reinforced plastic.

Global recognition did not come just from contracts. It came also in the form of an ISO 9001 Certification by Lloyd's Register Quality Assurance (UK) Ltd. SSE was the first shipyard outside Western Europe to receive this stamp of excellence.

Technology transfer through MINDEF's systems integration teams had helped SSE greatly but by 1993, SSE was ready to go it alone. The yard won the contract to design and build 12 patrol vessels of 55m length for the RSN. SSE now had its own weapons integration capability and could deliver ready-to-go vessels completely equipped with anti-submarine and anti-air suites, electronic warfare systems as well as complex weapon systems like the Harpoon missile.

(L to R)

1. Moving into the new area of air cushion vehicle technology, SSE designed and built the Tiger 40 Hovercraft, the first of its kind in Singapore.
2. Floating dock in Tuas Yard.
3. A contract for outfitting work on three mine counter-measure vessels led to SSE engineers and technicians being sent to Sweden for on-the-job training on glass-reinforced plastic.

(Opposite)
Hull cleaning, a laborious but essential step in ship maintenance.

Buying Time

When the British withdrew completely, business from the US Navy could not make up for the Royal Navy's withdrawal. Managing Director K.A. Middleton started an aviation electronics service, creating two wings – a general engineering wing and an aviation wing.

These meant that SEEL could serve private, charter and military customers. All this business kept SEEL just above water, but it could hardly be described as a profitable concern. By 1973, SEEL was in deep trouble. Twenty people had to be retrenched and SEEL even had to sell some of its assets in 1974.

H.J. Middeldorp from Philips Holland was sent in as the new Managing Director. He diversified SEEL into the distribution and maintenance of electronic products. It was a move to buy time, but it later helped SEEL when it moved into systems integration. However, part of SEEL's problem was the substantial cost of management. Thus, when Philips' contract as managing agent expired in early 1976, it was not renewed.

Local Hero

Lim Ming Seong, who was then the project director of the missile gunboat project at MINDEF, was appointed general manager of SEEL. With the backing of Cheong Quee Wah at MINDEF, Mr Lim was seconded to SEEL in October 1975. By then, management and labour were no longer talking.

"I met Peter Vincent, then President of the Singapore Electronic & Engineering Company Employees Union," said Mr Lim. "I think Vincent pitied me. He saw me as another local guy and perhaps more committed. I could work with him. I gave the union more things they needed, like scholarships for their children."

In the end, SEEL still had to retrench people. It was a painful moment for Mr Lim. He still remembers exactly how many – 14 men in all.

Mr Lim was not alone in his fight to save SEEL. Mr Cheong, on his part, tried to convince the new air force and the navy to use SEEL's services. The local aerospace industry was also starting up. A Systems

(Above)
Changi Airport was the first large-scale systems integration project for the private sector.

division in the Engineering department was started, as well as an Aircraft Electrical Overhaul shop at Seletar Air Base. By 1977, SEEL had become profitable.

Time to Grow

SEEL was soon to do its part for Singapore again in another significant way. In 1978, SEEL won the contract to do the Building Automation System for the new Changi International Airport.

"One of our managers had a very commercial bent, a non-defence outlook. So we tried for the Changi project. There was a main German supplier and we were the local partner. Now, if we had just sold the equipment to Changi, we would have made perhaps 5 to 10 per cent profit. But because we took it on as a project, we made 25 per cent," said Mr Lim.

SEEL also moved to a new home – a custom-built complex in Ang Mo Kio that expanded its engineering capabilities.

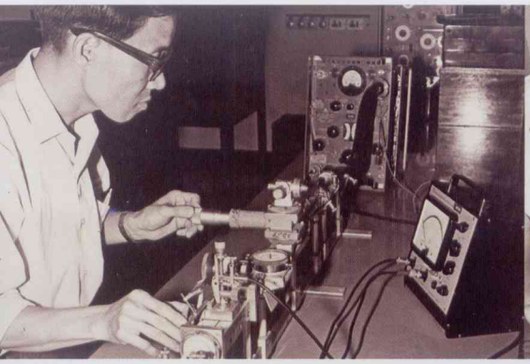
Support from the military came in two essential ways, when MINDEF decided to outsource the running of the Electronic Supply and Maintenance Base in 1981 and the Central Missile Supply Base in 1983. These would provide SEEL with steady income.

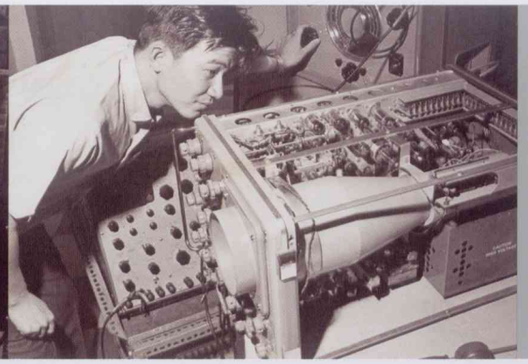
With the successful completion of the Changi Airport project under its belt, SEEL set up a joint venture with a German company to create computer-based systems for industrial tasks. SEEL survived longer than the joint-venture partner's parent company, but while the partnership lasted, it provided SEEL with electronic systems for major infrastructural projects. This gave a significant boost to SEEL's capabilities.

Pruning the Tree

In mid-1982, to rationalise the defence industries, Sheng-Li merged SEEL's Aviation Division with SAMCO's aircraft component repair business into a new company, Singapore Aero-Components Overhaul (SACO). SEEL would still deal with land-based electronics systems. Because of its aviation capabilities, SEEL itself was placed under Singapore Aircraft Industries (SAI), formed in 1980.

From this point, SEEL focused on major systems integration services. It went into non-defence areas such as building automation systems, like Changi





(L to R)
1, 2. Technicians carry out tests on special communications systems.
3. Electronics are central in runway lighting systems at Changi International Airport.

Airport's, and automated carpark management systems. It started making the components of these systems as well.

SEEL did not go completely commercial, however. Among the important projects developed for the military were flight simulators and support for radar and weapon systems for the air force, and support for the navy's communications systems, navigational aids and fire control systems. The navy's Combat Information Centre (CIC) for the corvettes was also supported by SEEL.

In 1986, a new joint-venture company, Singapore Engineering Software (SES), was formed between SEEL and the Swedish company, Ericsson Radio Systems AB. The joint venture would build more engineering depth, especially in software development for real-time command and control. In the long run, it would enable SEEL to tap into Ericsson's access to world markets.

New Name, Sharper Focus

In 1995, SEEL took on a new name – ST Electronics and Engineering. ST E&E began acquiring the electronic systems integration businesses of other companies in the ST group. The business now focused on providing the brains, sensors and nerves of fighting systems as well as the buildings and machines of everyday life.

Better, Faster, Stronger

Meanwhile, the quality of CIS's 5.56mm ball rounds eventually convinced the Swiss weapon manufacturer, Oerlikon Machine Tool Works, to commission CIS to produce a large order of 35mm anti-aircraft ammunition. It provided a key step up in the world of ordnance manufacturing. Over CIS's early years, foreign ordnance manufacturers turned to CIS to handle licence-manufacturing or subcontracted work. In the process, CIS's engineers and technicians learnt to develop and produce munitions of various calibres.

The Big Guns

Ordnance Development and Engineering (ODE) was started in 1973 to give Singapore the ability to design and build its own big guns in the future.

The year 1973 also saw the setting up of Allied Ordnance Company of Singapore (AOS) in partnership

The FH88 was unveiled in November 1988 when the Singapore Artillery received the first batch of indigenously-designed 155mm field howitzers.

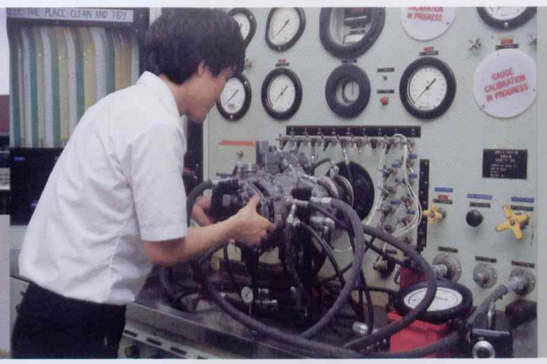
(L to R)
1. A technician inspecting the upgraded 40mm L70 NADM 330 naval air defence gun.
2. The 120mm Super Rapid Advanced Mortar System has the lowest recoil force in the world today.

with Bofors of Sweden, to make and sell quick-firing anti-aircraft (40mm) and naval guns (57mm) and their munitions and fuzes. When Bofors pulled out of the partnership in 1988, AOS became a wholly-owned CIS company.

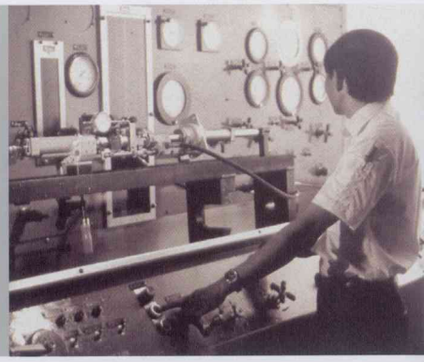
While AOS learnt from Bofors, ODE learnt by studying weapons that Singapore already had. Added to the knowledge gained from working with Oerlikon, ODE was well-equipped to take the long, hard road of weapon development.

SAF units today use many of ODE's products, such as the 40mm Automatic Grenade Launcher and various sizes of mortars, including a 120mm mortar with the lowest recoil force in the world today.

ODE also produced Singapore's first howitzer, the FH88, delivered in 1988. Designed to be crewed by fewer men, the FH88 was complemented by the FH2000, the world's first military-fielded 52 calibre 155mm howitzer. ODE then developed the Primus, a fully digitised 39 calibre 155mm tracked-based self-propelled howitzer, providing equal mobility and firepower to others which are significantly larger and heavier. This was followed by the Pegasus, the world's first



(L to R)
1, 2, 3. Singapore Aircraft Industries was the first company that housed all the aerospace business units, including SAEOL and SACO.



39 calibre 155mm howitzer with self-propel capabilities that can be airlifted by helicopter into the battle zone.

Is the Sky the Limit?

SAMCO was created in 1975 to support Singapore's air force. In 1977, SAMAERO Co Pte Ltd was formed as a joint venture between Société Nationale Industrielle Aerospatiale (SNIAS) of France and SAMCO. SAMAERO's job was to sell spare parts and tools for helicopters as well as support SNIAS products and the distribution of the Super Puma and Ecurueil helicopters. SAMAERO was renamed Eurocopter South East Asia (ESEA) in 2000.

By 1982, SAI had bought over SIA's share of SAEOL.

SAI became the first umbrella company that SACO, SAMCO, SAMAERO and SAEOL had come under. The main subsidiaries would later be renamed ST Aerospace Systems (STA Systems), ST Aerospace Engineering (STA Engineering), ST Aerospace Engines (STA Engines) and ST Aerospace Supplies (STA Supplies).

A turning point came when ST Aviation Services Company (SASCO) was formed in 1990 to join the foray into commercial work and spread overseas with the setup of ST Mobile Aerospace Engineering (MAE) in the United States.

Today, ST Aerospace and its subsidiaries do far more commercial than military work, but its first and primary mission is never forgotten. ST Aerospace continues its close relationship with the RSAF, supporting aircraft not just at depot level, but on the flight line.

This means that whenever and wherever an RSAF transport squadron goes on a humanitarian, peacekeeping or training mission, its supporting crew from ST Aerospace is always there.

Creating Structure

In 1981, MINDEF gave the go-ahead for the regrouping of companies within Sheng-Li into four main areas – Aerospace, General Services, Marine and Ordnance. This, however, was still considered insufficiently focused. In 1983, Philip Yeo drew up plans for Singapore Technology Corporation (STC) to bring together the manufacturing and service capabilities of the ordnance-related companies. STC became the holding company

(Clockwise)

1. The aerospace group entered commercial MRO with the setup of SASCO in 1990.
2. The group quickly spread its wings abroad with the setup of ST Mobile Aerospace Engineering (MAE) in 1991.
3. Today, customers like FedEx have their aircraft serviced in the United States and Singapore.

The Singapore Defence Industries Charter

In 1987, BG Lee Hsien Loong, then Second Minister for Defence, announced the Singapore Defence Industries (SDI) Charter to Sheng-Li executives. The Charter defines the role of the SDI, their relationship with MINDEF and their strategic thrust. An Executive Committee at Sheng-Li was also formed, with Philip Yeo as Chairman.

As Sheng-Li's companies grew, the SDI was necessary to remind the key decision-makers of their first priority as well as to open up other possibilities for them. The SDI was, in effect, both boundary marker and passport to new things.

The Sunburst: A Mark of Identity

Landor Associates was commissioned in 1988 to create a unified corporate identity so as to improve the group's positioning in the international market. After corporate restructuring and rationalisation, the new corporate identity and sunburst logo were launched in April 1989 to bring together the diverse companies under a common logo and the single brand name, "Singapore Technologies".

And in line with this name, on 11 May 1990, Sheng-Li was officially renamed Singapore Technologies Holdings (STH).

Going Public!

In 1990 BG Lee Hsien Loong, then Second Minister for Defence, announced that some component companies of STH would go public. The aerospace and marine companies went first, followed by the electronics and automotive companies the following year. The response was so enthusiastic that the initial public offerings were over 100 times oversubscribed. Subsequent listings of other ST companies would also see the same response.

for CIS (weapons and munitions), SAE (automotives), ODE (weapon and munitions development) and Unicorn International (defence marketing). Sheng-Li would continue to be the holding company of STC, SSE, SAI, SAFE (SAF Enterprises) and SFI (Singapore Food Industries). More restructurings would follow the proliferation of companies in both defence and commercial arenas.

Changing of the Guard: ST Engineering

Sheng-Li was itself renamed Singapore Technologies Holdings (STH) in 1990. This holding company, held by Minister for Finance Incorporated, came under Temasek Holdings in 1994. In 1995, Singapore Technologies Pte Ltd (STPL), the operational headquarters of Singapore Technologies, was formed to provide support and strategic direction to the companies in STH.

In 1997, the 30th anniversary of the start of Singapore's defence industry, Singapore Technologies Engineering was unveiled to the world. This latest restructuring would merge the defence-related subsidiaries into four strategic business areas (SBAs): aerospace, electronics, land systems and marine.

(L to R)
1, 2, 3 & 4. Signs of the times: These signs show the four strategic business areas under the Singapore Technologies Engineering banner.

The companies in these SBAs would naturally be experts in their own areas, but they would also be able to rely on companies in the other SBAs to help provide integrated solutions for both military and commercial applications.

Lim Ming Seong, who now heads CSE Global Limited, credits Goh Boon Seong with the idea for this reorganisation.

"Mr Goh worked for Prime Partners, a company that helped us with our initial public offerings. He noted that we were not getting full value from companies in the group and floated the idea of merging ST Aerospace, ST Automotive, ST Electronics and ST Marine to me. This restructuring would maximise the value of the companies."

Teo Ming Kian, STPL's non-executive Chairman from 1997 to 2004, said that restructurings, mergers and acquisitions were always difficult processes.

"When we did it, we had no illusions about the difficulty. People will see things from their own experiences and perspectives. It was a very deliberate rethinking and reviewing. In the end, people clearly understood the need for it. If we didn't have the resources of the whole group, we could not move ahead. The restructuring allowed individual companies to leverage on all the capabilities of the group. It's really a case of where the whole is greater than the sum of its parts."

The merger of ST Engineering companies was a very clear case of strength in unity. Boon Swan Foo, former President of SSE and later President of ST Aerospace, described it as a financial play to bring the companies together to create enough critical mass to get big fund managers interested in ST Engineering.

Engine of Change

CEO Tan Pheng Hock said that the creation of ST Engineering by bringing ST Aerospace, ST Electronics, ST Kinetics and ST Marine together has led to significant synergies.

"There are three reasons why we created ST Engineering. The merger meant that overnight as a group, we have 3,000 engineers, a much more credible engineering group. With this number of engineers, we now have breadth and depth of capabilities to engage the big boys of the industry and are able to deal with

(Above)
Chairman Peter Seah (third from right) with Tan Pheng Hock (second from left), General (Retired) James Coburn (right), Chairman, VT Systems, and Board members of VT Systems.

customers more holistically as we now have four business areas.

"Financially and in terms of capability, the Group is now in a better position to undertake bigger and more complex projects. In the process, we also avoid the duplication of effort in building up capabilities that straddle more than one SBA.

"For the first time too, we have the scale to consolidate some of our purchases, like insurance, and standard items like computers and IT systems. It also allows us to rationalise things in those areas that are less industry-driven which have particular requirements.

"For our customers, it helps us provide integrated solutions. Electronics capabilities, for example, straddle all the other three business areas. A recent example is the network-centric Bionix force. ST Kinetics builds the vehicles, ST Electronics provides the systems for command, control and communications – and intelligence too. The Landing Ship Tank (LST) was by ST Marine and ST Electronics."

The integration of the four SBAs also minimises the effects of business cycles. Mr Tan gave the example of SARS (Severe Acute Respiratory Syndrome), which in 2003 brought the airline industry almost to a standstill.

"That was a problem that was largely in Asia too," he said. "So by growing a global customer base, we are diversifying our geographical risk."

Mr Tan is familiar with the human cost of fluctuating business cycles. Less than a year after assuming his post as CEO, he had to retrench 460 people in ST Kinetics.

"Many were long serving staff, but I had no choice as the business environment had changed. It was a very difficult decision for me. No one knew how much I agonised over it because I did not show it openly. But deep inside, I could not accept having to ask staff to leave. I hope those affected understood why I had to do it and forgive me."

But with the combined strength of the diverse business units in ST Engineering, the Group was ready to take on the world in a much bigger way.

Going to America

"We also wanted to move away from reliance on defence contracts and get commercial and build our

(L to R)
1. General Coburn, Chairman of VT Systems, with visiting investment analysts.
2. VT Systems shares ST Engineering's global outlook and employs talents of many nationalities.

US operation," Mr Boon explained. The United States was one of the biggest markets for ST Engineering. But getting in was a challenge.

While the ST Engineering merger made the whole group much larger with a much bigger market capitalisation, it was VT Systems, established in 2000, that Mr Boon described as the "primer" for change. Although ST Engineering already had a US presence, through MAE and a sales and procurement office in Los Angeles, this was just one company providing maintenance, repair and overhaul (MRO) services for commercial aircraft, and not the full range of ST Engineering's capabilities.

"One of the main projects we used to try to enter and grow our US market was the Bionix," said Mr Boon. "It was a $5 billion contract. Although we did not win in the end, simply being among the shortlisted companies had tremendous market value. The world stopped to watch. It was a courageous and major marketing effort. We invested $10 million in it and spent nine months flying up and down. I was lucky to have BG (NS) Patrick Choy helping me – he's an exceptional military officer."

The ST Engineering team met many US armed forces commanders, visited bases and discussed manufacturing possibilities in the United States. Although the Bionix did not win the contract for the US Army's "Interim Armored Vehicle", the work put in by the ST Engineering team prepared the ground for the setting up of VT Systems in 2002.

General (Retired) John G. Coburn is Chairman and CEO of VT Systems. He joined VT Systems after retiring in 2001 as Commanding General, US Army Materiel Command (AMC). The highly decorated officer was already aware of the small company trying to get a contract for an armoured vehicle and that they had done well.

"Congress knew ST Engineering well," said General Coburn. "A congressman told me to join ST Engineering – they're great people, it's a great country, he said. A week or two later, another congressman told me the same thing."

In his 39 years of service, General Coburn got to know the leaders of many industries, big and small. The result was an unrivalled personal network that spanned political, military and industrial circles. With General

(L to R)

1. The addition of the Rosco brand road maintenance equipment has extended VT LeeBoy's product range.
2. VT LeeBoy production plant where its pavers are being welded.
3. VT LeeBoy's products include motor graders, pneumatic and drum rollers, multi-purpose asphalt maintainers and force feed loaders.

(Opposite)
VT LeeBoy is the industry leader in the United States for self-propelled commercial asphalt pavers.

Coburn at the helm at VT Systems, ST Engineering was well poised for its push into the US market.

Buying Halter Marine

A yard in the United States was essential as US law – the Jones Act – requires that any ship that plies between US ports must be built in the United States and crewed by US citizens. Having a US yard like VT Halter Marine meant that ST Engineering would be able to meet the requirements of the Jones Act.

BG (Retired) Boyd E. King, CEO of VT Halter Marine, joined when the yard was acquired by VT Systems in 2002.

"Change is always very hard – especially of this magnitude," said BG King. "But thanks to ST Marine's work, a lot of the apprehension was ameliorated. ST Engineering had a reputation for taking care of people and recognising its workforce and demanding high standards."

Buying Miltope

Miltope was owned by a Swedish company with a holding company in New York.

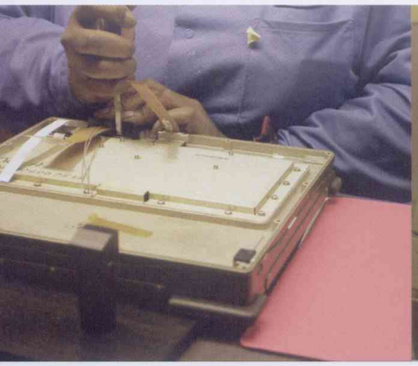
"They decided that Miltope was different since they were into cellphones and Miltope was into computers," said BG (Retired) Thomas R. Dickinson, the CEO of VT Miltope, which builds ruggedised computers for military applications. VT Miltope also builds other computing components that go into aircraft and other vehicles.

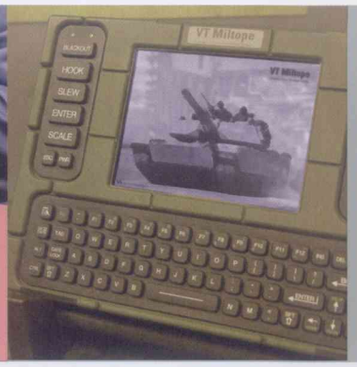
For VT Miltope, the change in parent company meant that it was now part of a global corporation that had branches all over the world. This added to their reputation as well as the stability of having the financial backing of a stable organisation.

"With ST Engineering's reach into the global markets, we were able to push our products to parts of the world we've never been before," said General Dickinson.

Buying LeeBoy

VT LeeBoy makes road construction and maintenance equipment for smaller roads. It has 60 per cent of the US market for commercial class pavers and wants to take that global. Owned by an equity firm, LeeBoy was sold to VT Systems in June 2006.





(L to R)
1. No ordinary laptop: VT Miltope ruggedised computers for military use.
2. Computers used on the battlefield need to be as tough as tanks.
3. VT Miltope headquarters in the United States.

"My people were very excited," said President and CEO Kalvin (Kelly) Majeskie. A family-owned business till 2000, VT LeeBoy's employees are from the area around the facilities and are steeped in tradition.

"They were a little apprehensive at first," said Mr Majeskie. "But I've lived in Singapore, so I could tell them about the culture in Singapore – how business people there were smart and good. ST Engineering would be a partner who could provide direction and opportunities in the global market."

Buying iDirect

ST Engineering acquired iDirect, a US-based leading maker of two-way Internet protocol-based broadband satellite networking solutions, in 2005.

iDirect's customer base includes over 100 companies in the telecommunications services, oil and gas, construction and marine industries, as well as government agencies. Founded in 1994, it has corporate headquarters in Herndon, Virginia, and offices in Canada, the United Arab Emirates, the United Kingdom, Italy, Hong Kong SAR and Singapore. iDirect also covers Latin America. iDirect was named number one in the Deloitte & Touche Virginia Technology Fast 50 list of the fastest-growing US technology companies in 2005.

"iDirect extends ST Electronics' presence in the United States and propels us ahead as a leading global satcom solutions provider," said Seah Moon Ming, President of ST Electronics and Co-Chairman of iDirect. "We now have a comprehensive satcom product offering with the integration of iDirect's satcom network equipment and our existing satcom front-end transceiver, marketed under our established Agilis brand."

Buying MÄK Technologies

Intent on growing its simulation technology, ST Electronics acquired 80 per cent of US-based MÄK Technologies, Inc. in 2006.

Rapid technology advancements have accelerated the convergence of simulation and digital media technologies, for example in games and animation. MÄK Technologies, as a frontrunner in incorporating

(Opposite)
iDirect provides satellite networking solutions.


iDIRECT

(L to R)

1, Suzhou, China, may be famous for its canals, but its roads are just as smooth-flowing, thanks to the Suzhou City Traffic Management system installed by ST Electronics.

2. Guangzhou MRT system benefits from ST Electronics automatic fare collection system.

games technologies into simulation technologies, will further spur ST Electronics' thrust into the digital media business. The acquisition also provides a channel for ST Electronics to commercialise and distribute its complementary simulation intellectual property.

As Warren Katz, CEO, and John Morrison, CTO of MÄK Technologies, put it, "We're pleased to become a part of the ST Engineering Group because ST Engineering has significant intellectual property in the simulation space that we intend to commercialise and make available to our over 400 customers. This will both help our company grow faster, as well as provide a wider selection of more fully featured products."

Growing in China

China is a producer and a market the world cannot ignore. ST Aerospace and ST Electronics were among the first of the companies to make business forays into China. ST Aerospace began marketing and getting sales in the 1980s and ST Electronics by the early 1990s, even before the formation of ST Engineering.

From a small presence and its first milestone project for an Intelligent Building Management System

(L to R)

1. A pioneer manufacturer of off-road dump trucks, BZK has sold more than 4,000 of these vehicles in China.
2. BZK's dump trucks are used in mining operations and in the construction of hydro-power generation plants.
3. GJK services an international market with its quality products, competitive pricing and excellent after-sales service.

for the Jin Mao Building in 1998, ST Electronics grew and now has presence in Beijing, Chengdu, Guangzhou, Hangzhou, Hong Kong, Qingdao, Shanghai, Shenyang, Shenzhen and Yichun.

ST Electronics continues to develop its business in China in the areas of satellite communications, intelligent transportation systems, MRT solutions, public safety and e-Government solutions and intelligent buildings and homes as its core business in China. It became the first Singapore company to be awarded a major infrastructure project for the Beijing Olympics 2008 when it won a contract to implement an Integrated Traffic Command Centre System that will provide central control for the rapidly growing Beijing mass transit network.

Partners in China

Guizhou Jonyang Kinetics (GJK) is a case of two willing parties looking for each other. ST Engineering was keen to expand its global presence, while Guiyang City Industrial Investment Holding Corporation (GIIHC) wanted to take itself to greater heights. GIIHC's President, Fang Chong Ping, was an expert in excavators and had read a lot in trade magazines about a company called ST Kinetics. He was impressed by ST Kinetics' long-term view of things as well as their long experience. Eventually, both sides agreed to set up a joint-venture company which was officially established in 2005. It is ST Kinetics' biggest joint venture in China to date.

Workers of the former state-owned enterprise were initially taken aback by the demands of the new management style, but quickly adjusted to the new working conditions. Turnover and profit for 2005 was double that of 2004, before the joint venture. Smaller companies to which GJK outsourced work also benefited from its success, as did other supporting industries. And to top it all, GJK received an award in 2007 from the municipal government for being one of the best-managed companies in the area.

"We know that ST Kinetics is enhancing its global presence and we are a test case in China," said Mr Fang. "So we can really help with our insight and experience. With us, ST Kinetics will also have a better understanding of the trends of China's economic development and potential markets."

(Left)
GJK designs, manufactures and distributes a range of wheeled and tracked hydraulic excavators, as well as customised specialty machinery and vehicles.

Besides GJK, ST Kinetics has another joint-venture company, Beijing Zhonghuan Kinetics (BZK), incorporated in 2004, that designs and produces off-road dump trucks for the mining industry. Again, transformation similar to GJK's was evident.

Growing Global

ST Electronics had been selling its Agilis brand VSAT (Very Small Aperture Terminal) equipment worldwide, and marketing and manufacturing in China even before the more recent push into the United States and China.

Likewise, ST Aerospace, which started its first move overseas in 1990 through the setup of MAE in the United States and ventured into the United Kingdom to establish Airline Rotables Limited (ARL), continued to grow its global MRO network. It continued its work in China, setting up a joint-venture company with China Eastern Airlines called Shanghai Technologies Aerospace Company (STARCO), acquired a majority share of SAS Component (SAS Airlines' component repair company) and, in 2006, set up a new aircraft maintenance facility in Panama.

All This Is Ours

Siow Keng Cheng, former President of ST Electronics' Asia Pacific Operations, first joined the company in 1972.

"Singapore was not really developed in the area of electronics when I started work. An electrical and electronics engineer had only two choices – work with broadcasting or telecommunications equipment. But in the 1970s, the electronics industry began to stir with Texas Instruments and National coming to Singapore.

"I could have joined an MNC, but there's more satisfaction in seeing a local company succeed simply because it is our own. We contribute there, we belong, we have a better future. If it had been run by our old-style towkays, I would have had a different view of things. But this was a government-linked company so the scope of work was a lot bigger. With an MNC, you won't have the same sense of ownership, but with a local company like ST Electronics, you do. We are Singaporeans, this is a Singapore company, you are free to make decisions, start up new businesses, go abroad to work.

"Many of my colleagues were also pulled in from the armed forces. They had a certain sense of discipline about them already. They were committed and trustworthy, much better than just someone off the street or fresh from school. They had the grounding and loyalty to the country. You cannot put a measure on something like that.

"I think we are all proud to have contributed and helped make ST Engineering what it is now."

It has been more a case of "growing global" and not just "going global" in the 21st century. Each new company, joint venture, facility, factory, representative office or distributor does more than add to ST Engineering's capabilities and bottom line.

Leveraging on the same communications technology they bring the world, ST Engineering is also using the synergy that results from a global workforce.

"Development work can actually take place 24/7," said CEO Tan Pheng Hock. "In the case of the Passenger-to-Freighter conversion plans, when Singapore sleeps, the US is at work. Everything is done through information technology. Teams on both sides share the same database and software."

But what is being shared across global boundaries is more than just hardware and software. ST Engineering's core values of Integrity, Value Creation, Courage, Commitment and Compassion are now being propagated through its acquired companies and joint-venture partners around the world. It adds up to a global team that a customer can count on to deliver consistently excellent quality in both products and services under the ST Engineering banner.

(L to R)

1. ST Aerospace expands into China through a joint venture with China Eastern Airlines.
2. STARCO, the joint-venture company, provides aerospace MRO for civil aircraft.
3. ST Aerospace further increased its global footprint with the acquisition of SAS Component in 2006.

Creating Value by Having Values

It is not unusual for a company to have a set of Vision, Mission and Values and ST Engineering is no exception. What makes ST Engineering's VMV special are its Values, which have been shaped over the last 40 years as professionals – and just as people.

Vision and Mission are mutable, as Lionel Guow pointed out.

"The Mission and Vision are the direction set by our management and leadership in order to align and focus our efforts. This can change over time in order for the company to stay relevant in a changing business environment. However, the guidance provided by the set of core values is timeless and will be relevant always."

When asked to identify which part of the VMV strikes them most, staff most often refer to the values. And more than one said that it was more than just a set of company values. It was also a good set of values to live by. There could be no better endorsement for a set of company values.

ST Engineering's values are:

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 do 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 hands and to contribute to that small bit of change for the better. Courage overcomes the fear of change, promotes out-of-box thinking and hence, innovation and creativity.

Commitment – Commitment is the spirit that drives energies positively against seemingly impossible odds to achieve extraordinary results. It sustains the drive and keeps our standards flying.

Compassion – In our drive to succeed as individuals and organisations, we will fail to bring value to others unless we empathise with 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.

Balancing Profits and Principles

ST Engineering's Board of Directors takes the value system one step further, applying them in the way it oversees the Group's operations.

Compliance with the laws of Singapore or a host country is not just a matter of form. The Board believes that the spirit of those laws must be adhered to when putting systems and processes in place for self-regulation.

Transparency, timely disclosure and accountability are what it takes to deliver good leadership, effective strategy and robust performance. Open debate and objectivity are the norm when decisions have to be taken.

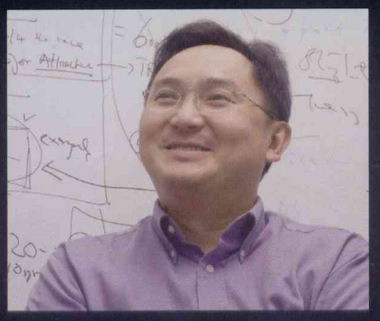
Besides doing business ethically, which is a given, the Group also seeks to be a good corporate citizen wherever it operates. Safety, care for the environment, corporate governance and transparency, education, and support for the arts and sports – even assisting in emergencies – are some ways ST Engineering can contribute to its host community. Demonstrating sensitivity and respect for people, communities and the environment, the Group knows that business can never be just about profit.

"The most important quality I have observed here is compassion. One of the major reasons I am with the company is because of the selflessness of colleagues who willingly encourage each other, help each other and teach each other. That is a culture that money cannot buy."

Fiona Loke
Engineer, ST Electronics (Info-Comm Systems)

"Courage strikes me as the most important of our values, as my current work requires me to deal with the exploration of new technologies, research and development, and to make business sense out of them. Failures bring guidance and courage brings success."

Jimmy Chan
Principal Engineer, Kinetics Design & Development, ST Kinetics



"Some of the most important lessons I have learnt throughout my years with ST Electronics were those of courage and persistence (commitment). More than often, it was not only the experience or even the right expertise that made things happen. It was always the 'can-do' and 'never-say-die' spirit that helped us realise the visions (our missions), and survive and carry through the hardest of challenges."

Lee Wee Song
General Manager, ST Electronics (Thailand)

"I enjoy every moment of my work because everyone from CEO to workers treats me with respect. The company has also been a generous employer."

Mohd Yusoff B Mohd Arif
Driver, Advanced Material Engineering, ST Kinetics

"What strikes me most is the vision of being 'world class'. We live this out on a daily basis as we find ourselves partnering with and, at other times, competing with companies that are broadly considered to be 'world class'. This can be seen in some of ST Electronics' project wins in recent years where we have had to bid against other well-respected multinational corporations. Through our share of successes and failures, we are continually learning how to do business more competitively in the global economy."

Kevin Cheng
Deputy Director, Homeland Security Division, ST Electronics (Info-Software Systems)

"I would rate Integrity as the most significant value that a company must have to achieve its vision. It is this value that will fuel the company to greater heights. I always believe that people with the correct value set are the most important assets of the company and should always be valued. In the course of work, there are customers who always give us the first right of refusal for any requirements or problems that they may have. I always see customers' problems as opportunities for our business. I consider this a value that we should always cherish and maintain."

G. Selvaraj
Manager, Defence Business, ST Electronics (Info-Comm Systems)

"What moves me most about the company is its values. Compassion, integrity, value creation, commitment and courage. These are humanistic qualities that make us a better people. I am learning to live out such qualities in my life."

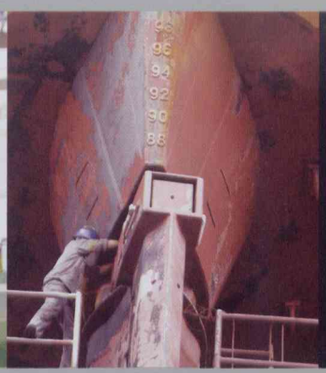
Gladys Ratnam
Library Officer, Quality Assurance department, STA Engines


Keep It Glowing

The bringing together of ST Engineering's disparate companies into a unified group clearly has advantages for the Group and its individual members. More importantly, the integration serves the needs of the customer, providing a "one-stop centre" for many vital services and products. It saves the customer effort, time and money. And when the work is recurrent, like maintenance, this convenience and economy can add up to significant savings in time and money in the long term.

However, the unity of ST Engineering's many subsidiaries involves much more than one-stop convenience for customers. It is a philosophy that runs deep through the Group and extends to how staff work with each other and how the Group works with customers. It should not be surprising though, given the Group's reason for existence – to support the SAF and MINDEF in developing and maintaining Singapore's capability for self-defence.

ST Engineering is a united Group that provides its customers and people support all the way.



CHAPTER TWO

(L to R)

1. STAR China is set to capture the vehicle maintenance market, a growing business as affluence increases.
2. Rudder work being done on a ship.
3. The Group has a diverse base of aviation customers – airfreight operators, air forces and airlines.
4. Trains depend on electronic systems to run on time.

Within and Between...

In ST Engineering, there must of course be integration between the companies in an SBA – Aerospace, Electronics, Land Systems or Marine. Integration, for the Group, is not only within each sector, but across sectors as well. The Group can draw on skill sets and solutions across all sectors, as exemplified by the Landing Ship Tank project, to provide military and commercial customers with fully integrated solutions.

...and Abroad

Overseas subsidiaries are part of the family. But crossing international boundaries also means crossing the lines of local customs, language and corporate cultures. Many subsidiaries are new members of the family, but the Group is working towards being a truly global company, where employees will be internationally mobile,

Merger Created Opportunities

"The merger of Temasek Holding companies in aviation, electronics, land systems and marine sectors into ST Engineering and the formation/acquisition of many new overseas companies have led to phenomenal growth. The changes created new challenges and opportunities for me and my colleagues. Engineers were faced with a lot more choices to move ahead either in technical or management areas, in Singapore or in overseas ventures. Numerous collaborative programmes and partnerships with reputed overseas companies opened up challenging opportunities for professional and career development."

Thomas Jeyaseelan
Chief Engineer (Structures),
ST Aerospace's in-house
Engineering & Development Centre

The Group is located in key aviation hubs to support customers worldwide.


AIR CANADA
The World On Time
FRAGILE

(L to R)
1. An aerial view of the San Antonio Aerospace in Texas.
2. Well-trained people enable ST Engineering to optimise the support of customers.
3. The door surround structure being installed during Boeing 757 passenger-to-freighter conversion work.

(Opposite)
ST Aerospace works closely with customers to minimise their cost of ownership by improving turnaround time and maintenance lifecycles.

thanks to integration. Although this has still to happen, the SBAs have already made inroads into global integration. For example, both American and Chinese subsidiaries are working to open up markets for each other's products as well as combining capabilities to create new products and services.

With Suppliers and Partners

The close relationship extends also to suppliers and partners. Long-term relationships are forged with reliable partners – or partners who find ST Engineering reliable. Aircraft-maker Boeing, for example, has grown close ties with ST Aerospace, and today trusts ST Aerospace not just with the maintenance and conversion of its passenger aircraft such as the MD-11 and Boeing 767, but also works with ST Aerospace to develop the supplemental type certificate for the conversion of its Boeing 757 aircraft.

The Group also takes pride in being a great systems integrator, one of its long-standing capabilities. Using different subsystems from a wide range of suppliers, the Group makes all of these systems work together harmoniously to provide tailor-made solutions for customers. Integration with suppliers translates into a multitude of possibilities for customers.

Working with the Customer

ST Engineering's people do not just work for a customer – they work with a customer too. This integration is focused on giving the customer the best services and products possible. This is especially important, given the nature of ST Engineering's products and services, to fulfil their very specific requirements.

This is the kind of integration that ST Engineering veterans are most familiar with, thanks to the Group's long-standing relationship with the SAF and MINDEF. ST Engineering's military roots are present in every sector it works in. Beginning with the maintenance of SAF's vehicles, RSAF's first aircraft and SAF's radio communications sets, ST Engineering has grown into a global company with more of its revenue coming from commercial sources than from the military. But serving the military was the central purpose of ST Engineering's pioneer companies and today, the Group carries on this fine tradition of military support. The military

(L to R)
1, 2, 3. Every work process – be it on an aircraft structure, engine or any component – is critical. At far left, a CFM56 engine is being readied for a performance test in one of STA Engines' testcells.

(Opposite)
The Group is committed to always look at quality from customers' perspective.

also benefits from ST Engineering's commercial work. The Group taps on commercial technology, using off-the-shelf systems, subsystems and best practices.

Keeping Aircraft Flying Safely

"We Keep Aircraft Flying Safely". It is a simple statement painted in large letters on hangar walls, but it says everything about ST Aerospace's commitment to quality work. It is this rudimentary philosophy that has taken ST Aerospace from its humble beginnings in providing depot maintenance to the RSAF, through its evolution to offer maintenance, repair and overhaul (MRO) services for commercial aircraft operators in 1990. Today, it has established itself in key hubs in the Asia Pacific, Europe and the Americas. Its present global customer base includes many of the world's advanced military forces, major airlines, leading air freight operators and low-cost carriers.

ST Aerospace is the world's largest airframe MRO provider, with an annual commercial airframe capacity of more than eight million man-hours.

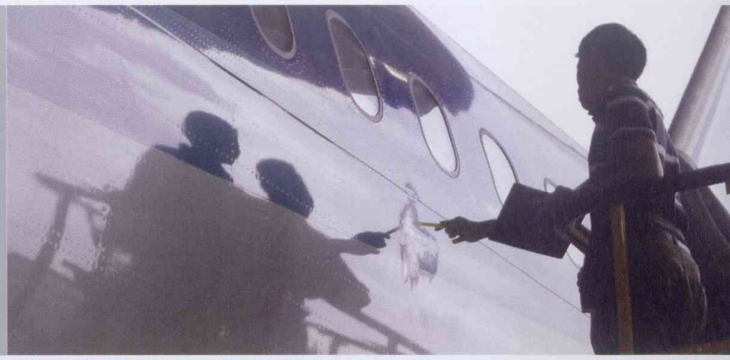
Through its operational divisions, Aircraft Maintenance and Modification (AMM) and Component and Engine Total Support (CETS), the aerospace group of companies supports line and base maintenance, engine and component maintenance, and engineering and material management services for a wide range of aircraft types, including technical services and maintenance planning for aircraft operators.

The company also provides diverse aircraft component management and support services, including warehouse and material management, Aircraft-On-Ground (AOG) spares and service support, aircraft parts trading, aircraft operating lease and Original Equipment Manufacturer (OEM) representation.

Leveraging on the integration of these broad-based capabilities from AMM and CETS, ST Aerospace presents customers Total Aviation Support (TAS™) – or its one-stop centre solution – offering high quality, value-added and flexible solutions to meet customers' aviation maintenance and engineering needs. From depot-level maintenance, interior refurbishment, systems integration and retrofits to test flight support services, customers get a comprehensively seamless experience.

Paperwork is no small matter in aircraft maintenance. It is an integral part of the quality system that consistently delivers reliable, on-time and cost-effective support, earning ST Aerospace the ongoing patronage of leading aircraft operators.

(L to R)
1. ST Aerospace provides Total Aviation Support for Skybus, a new US budget carrier.
2. Thorough inspection of an aircraft exterior.



Delivering on-time and value-added support, ST Aerospace is the choice of many operators because its level of service and quality improves turnaround time and maintenance lifecycles. ST Aerospace mitigates aircraft down time and maximises financial potential for customers.

Maintenance-By-the-Hour

"You would think the more often an aircraft comes in for maintenance, the better for the MRO company," said Ho Yuen Sang, Deputy President of ST Aerospace. "But with the Maintenance-By-the-Hour (MBH™) scheme, the MRO company is paid for every hour the aircraft can be operated before it comes in again. This means that the better we do our job, the more we get paid – and the less we have to do.

"So we must manage the asset properly. A maintenance plan is usually prepared by the airline, not by the MRO company. However, some operators may not have the resources to do this, for example, low-cost carriers. As the MRO provider, we keep track for them and provide them with a list of tasks to be carried out when the aircraft is sent in to us."

Anticipating Needs

"Our technical services people study defects, reliability and so on, and work out the time to failure so that they can anticipate the failures and change the components before they fail," said Mr Ho. "Catching it before failure saves cost and facilitates planning. So today, an airline does not need to tell us when or what to do. We can help them plan their maintenance schedules.

"With today's need for high utilisation of aircraft, an airline cannot afford to have its aircraft grounded for too long. We've worked out a system of equalised checks – instead of a hundred tasks to be carried out over five full days, we now divide the hundred tasks into ten packages, each of which we can do overnight when the aircraft is on a layover. This really helps us to support low-cost carriers and new start-ups more effectively."

Combat Wings

ST Aerospace's revenue today comes more from the commercial than the military market, but it is still a company that is deeply integrated into the RSAF. The RSAF's key assets – its aircraft and their avionics

The Group continually updates and upgrades its people to deliver the highest quality services to customers.

Upgrade Everyone

Philip Lee Soon Fatt, Service Engineer, STA Systems, still remembers how, in 2000, the Group wanted to computerise many of its corporate services functions. To help every staff member become computer-literate, they had to ensure everyone had some form of training and practice.

"So they gave us computers," said Mr Lee. "Every one of us got $2,500 to buy computers and peripherals. This was Boon Swan Foo's idea. And because of that, many of us finally learnt how to use a computer. Every one of the 3,000-plus staff got that money for computers, even the newly-employed ones."

Today, everyone in the organisation is computer-literate, thanks to the educational system's emphasis on this – and ST Engineering's willingness to support its staff. It also gave the families of staff access to computers – vital in Singapore's drive to make every citizen computer-literate.

"On the issue of training – we do a lot of that in-house, with some overseas training and development stints," said Mr Lee. "It's difficult to get trained people in our field. Today, we have a good mix of nationalities – Chinese nationals, Filipinos, Indian nationals, Hongkongers. We also train staff from other facilities, for example, the Shanghai side will be sending men over to us for training."

Serving Customers Wherever They Need Us

ST Mobile Aerospace Engineering (MAE) is a facility based in Mobile, Alabama, USA. Situated at the Brookley Industrial Complex, MAE specialises in the heavy maintenance and modification of commercial narrow-body and wide-body aircraft. MAE was the first commercial operation in ST Aerospace's group of companies outside of Singapore. It is renowned for its expertise in PTF conversions, including Boeing 727, Boeing 747 Combi, Boeing 757, MD-10 and DC-10, and a specialist in heavy maintenance.

San Antonio Aerospace (SAA), located at the San Antonio International Airport in Texas, USA, provides maintenance services, interior retrofit and reconfiguration, structural component repair and overhaul as well as avionics upgrade services for a wide range of commercial narrow-body and wide-body aircraft, as well as regional jets.

Shanghai Technologies Aerospace Company (STARCO), ST Aerospace's foray into China in 2004, is a joint venture between ST Aerospace and China Eastern Airlines. STARCO's two-hangar facility at the Hongqiao Airport in Shanghai handles commercial airframe maintenance and modification services for a wide range of aircraft, and looks to expanding into a second location at the Pudong Airport.

SAS Component was acquired in 2006 to enlarge the component repair service offered in Europe. Combined with STA Supplies, STA Systems and Airline Rotables Limited (ARL), a specialist provider of A320 and Boeing 737 rotables inventory management, ST Aerospace now has an expanded global coverage. SAS Component provides aircraft components repair, management and logistics services.

Panama Aerospace Engineering (PAE) is the latest facility of ST Aerospace, having opened only in 2007. It specialises in heavy maintenance, modification and repair of commercial narrow-body aircraft.

San Antonio Aerospace is currently one of ST Aerospace's four airframe facilities outside Singapore.

Support Wings

Aerospace Engineering Services (AES) is an associate company of ST Aerospace based in Western Australia. It is the prime contractor for support services to the RSAF's flying operations in Pearce Air Base, Western Australia. Pearce Air Base is where the RSAF's pilots-to-be get their first taste of military aviation on the S211 jet trainer.

Koh Joo Ming (Assistant Manager, Quality Department, STA Engineering) is particularly proud of his work at Pearce.

"I was posted to Perth in 1993 as part of a pioneer group to start up the S211 Commercialised Programme. I was responsible for the Quality Section and worked to attain the ISO 9002 Quality Systems certification in 1994.

"The expectation from the RSAF is high. I still vividly remember that we achieved 888.88 flying hours, which was the highest monthly hours achieved ever in the S211 programme. The other great experience was being an audit team member among auditors from RSAF, STA Engines and STA Systems, to jointly audit and select vendors in Australia.

"'We Keep Aircraft Flying Safely' – this is the phrase we should be proud of."

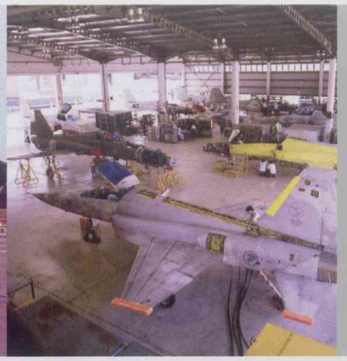
Pacific Flight Services (PFS), an STA Engineering subsidiary which in turn is a subsidiary of ST Aerospace, specialises in towing and auxiliary services for military training. Air force pilots assigned to the Transport Wing Programme come to PFS to train on a twin-turboprop transport aircraft after their basic flying training.

PFS also provides tow-target services as well as executive charter and medevac services using the Learjet 35 and the Learjet 45.

Tan Chin Kian, a flying instructor at PFS, says the RSAF keeps a sharp eye on the training. "They can drop in anytime," the ex-RSAF officer said. "They can come on board the aircraft and observe the training. This is because the programme is also meant to teach military values, safety values, officer values and cockpit etiquette, besides basic and tactical flying skills."

His fellow instructor, Steven Chua, also a former RSAF pilot, said flying with PFS is not too different from flying for the air force.

"Flying is a profession," he said. "Wherever you go, the same professionalism is needed."



(L to R)

1. ST Aerospace has the capability to handle MRO even for sophisticated jet fighters like the F-16.
2. F-5 jet fighters undergoing phase servicing at Paya Lebar.
3. ST Aerospace capability extends to rotary wing platforms, including the Super Puma.

(Opposite)

1. An S211 jet trainer rolls off the flight line at Pearce Air Base.
2. Koh Joo Ming, Assistant Manager, Quality Department, STA Engineering.
3. PFS flying instructors Tan Chin Kian (left) and Steven Chua.

– are still purchased from foreign sources, in particular, the United States. There are few MRO companies that can handle these high-performance air force planes and the integration of the foreign avionics systems and weapons.

Aircraft also need far more servicing than land vehicles or ships. Thus, military aircraft operators also enjoy quality service with ST Aerospace, which provides convenient one-stop maintenance services for the C-130 Hercules aircraft, A-4 Skyhawk and F-5 Tiger fighters.

ST Aerospace's subsidiary and specialist in military aircraft MRO, STA Engineering is also an Authorised Service Centre for the Lockheed Martin C-130/L-100, Bell helicopters (all models), and Eurocopter Super Puma helicopters.

In addition, ST Aerospace's engine support capability for military aircraft covers General Electric's J85 and F404 engines, Pratt & Whitney's F100, Honeywell's T53 and T55, Rolls-Royce's T56, Turbomeca Makila and Arriel engines. Services also include military avionics upgrades and technologically advanced upgrade solutions.

ST Aerospace's extensive experience and firmly established reliability in aircraft safety have earned it not just the necessary certifications to work on these aircraft, but also the respect of the RSAF and foreign air forces. ST Aerospace today has a proven track record and MRO expertise in a wide range of military aircraft types, including A-4, C-130, F-5, F-16, F-50, KC-135 and S211.

Staying Shipshape

What sets ST Marine apart from other shiprepair facilities is that it has grown to become a premier shipyard that provides turnkey shipbuilding, ship conversion and shiprepair services to customers all over the world – commercial and naval.

ST Marine offers modern facilities with a combined area of 18.8 hectares, equipped to construct vessels up to 30,000 dwt, and service up to frigate-sized warships and 70,000 dwt Panamax-sized commercial vessels. (A Panamax vessel is one that can pass through the Panama Canal.) The main yard at Benoi is primarily for commercial and naval newbuilds while the nearby Tuas yard is used for repairing commercial vessels.

(Above)

1. The ST Aerospace crew from the first OBO stand proudly before their charge, a C-130H Hercules.

2. ST Aerospace technicians with a KC-135R during a recent OBO detachment.

Side by Side: Operation Blue Orchid

Operation Blue Orchid (OBO) is Singapore's contribution to the reconstruction of Iraq. Beginning in 2004 with a C-130, Blue Orchid has since 2005 contributed a KC-135R air-refuelling tanker to the effort every year. Air force crews fly the aircraft and ST Aerospace teams keep it flying. It is a fine example of integration between the RSAF and ST Aerospace.

Of the men sent on each three-month deployment or "frame", almost half are ST Aerospace engineers and technicians. Chin Kean Hee, an airframe service engineer, has been on three Blue Orchid frames.

"I volunteered because it was challenging," he said. "The work is the same, but made tougher by the heat. The weather saps your energy. Back home in Singapore, we do see the aircraft that we work on fly in and take off, but here, there is an added feeling of satisfaction that we're doing something for the world."

The operation sees the men working outdoors all the time as there are no hangars at the airbase. Temperatures can go beyond 40 degrees Celsius.

"My family's used to it – and of course, I call back every night. I've missed some important things, like my older daughter's university graduation. And I miss them too," said Mr Chin. Of the OBO fraternity, he said: "The air force crews and ST men, we're more than a club – we're one big family."

"It's a hostile climate," Danasekaran, Detachment Engineering Officer in OBO, said of working conditions in the desert. "The fact that we work in the open is made tougher by the high winds and sandstorms. It invariably slows you down for any job you undertake. The components are fragile and we have to take lots more precautions. We had to develop new standard operating procedures for this.

"Every time we launch an aircraft, it's very gratifying to see the aircraft come back safely."

The need to keep the KC-135R ready to go is a challenge in the tough conditions.

"An aircraft challenge is never the same," Danasekaran said. "It can be a minor job or something quite major, but doing it in a desert environment makes it tougher. The fine sand is a real problem."

But he admits he would love to go again.

"Our relationship with the air force is very good. We're there as one entity. The air force guys took very good care of us, there were no demarcations. We shared everything – equal misery, equal joy!"

Lieutenant-Colonel Sivaraman Rajan, the Commanding Officer of 112 Squadron, has been on every OBO frame. Of the KC-135R, he said: "It was also the first time we were operating the KC-135R at such a high operational tempo," he said. "But in the last two years' frames – 2006 and 2007 – we've been able to fly 100 per cent of our assigned missions."

He gives credit to ST Aerospace's men.

"The ST Aerospace men have a very high sense of professionalism. Their commitment to ensuring a good job shows. They see themselves as part of the squadron so they are very motivated to keep the aircraft serviceable and good for missions.

"The sense of camaraderie is strong among all the men. There is a lot of interaction both professionally and socially. They all do things together, like going shopping for souvenirs, food and electronics!"

Missile gunboats undergoing repair at Benoi Yard.

(L to R)
1. A dredger undergoing repair.
2. A tanker being converted into a Floating Production Storage Off-loader (FPSO).
3. A cruise liner in for repairs.

(Opposite)
Bird's eye view of the Tuas Yard floating docks.

ST Marine's US arm, VT Halter Marine, is adding to the order book with newbuildings from the Americas. With its yards in the Mississippi Gulf Coast, VT Halter Marine's own 50-year history and reputation make a fine complement to the Singapore-based yards. It is a proven leader in the United States in the design and construction of ocean-going vessels up to Panamax in size, such as patrol vessels, logistics support vessels, research vessels, oil cargo vessels, offshore supply vessels and ferries.

A wide range of vessels come through Singapore for repairs. Bulk carriers, RoRo vessels, dredgers, seismic vessels, offshore supply vessels and cruise liners are among the many types of vessels that use ST Marine's excellent facilities and services.

ST Marine has developed a reputation for quality shiprepair and personalised service for customers. This has helped the company establish leading positions in the dredger and chemical tanker market segments.

Supporting the Navy

Besides maintenance and refitting of naval vessels, ST Marine also does damage repair and provides specialised services such as weapons upgrades, mid-life conversions and servicing for high-speed diesel engines. Originally set up to serve the RSN and the Asian merchant marine market, ST Marine's impressive facilities today serve the world – as well as the navies of some countries. The naval customer base includes the French Navy, the Royal Brunei Navy, the Royal Thai Navy, the US Coast Guard and the US Navy.

Of course, the RSN is still top priority for ST Marine. RSN personnel rotate from shipboard service to ST Marine for shore stints where they learn about the latest techniques and equipment.

The RSN's submarine capability is also supported by ST Marine.

"Submarine maintenance is closer to aircraft maintenance in nature," said See Leong Teck, President of ST Marine. "On a surface vessel, should a system


BW25
BW24

(L to R)
1. ST Marine also supports the RSN's submarine maintenance.
2. A jack-up rig in for repair.
3. Conversion of VLGC *Gas Concord* from LPG carrier to LPG FSO.

(Opposite)
The rudder and propeller of a commercial vessel being inspected.

break down, the vessel will still float. But you cannot take that kind of chance with a submarine system. The submarine, like an aircraft, could just go down."

In the unlikely event that a submarine should go down and crews need evacuation, the company provides a vital service in the area of submarine rescue. ST Marine has a S$400 million contract to maintain a submarine rescue capability – an essential service in both war and peace. The priority is on saving the crew, not the submarine, which can always be brought up by salvage teams.

Even though this service is absolutely essential to the safety of submarine crews and their vessels, it is not feasible for the RSN to maintain a capability that hopefully they will never need. A large group of technicians and crew to support and operate the rescue submarines and vessels would go counter to the policy of putting every available man in a combat job. Outsourcing this vital rescue function frees personnel and other resources for combat roles. Furthermore, ST Marine can put submarine resources to work in a commercial situation, for example, salvage and repair.

Keep Them Operating

From the early days at CIS of making bullets and SAE of maintaining V200 armoured vehicles, the two entities have grown separately over the years to design and produce their own products. Today, the merged entity of ST Kinetics is one of the largest land systems and specialty vehicles companies in Asia, delivering engineering excellence through three business groups.

The Land Systems and Solutions (LSS) group helps to maintain the peace of nations through its portfolio of defence products while the Specialty Vehicles and Services (SVS) group helps to raise the productivity of its end users through its array of specialty vehicles and equipment. The third group, Total Support and Services (TSS), strives to maximise the availability of the assets of its customers through its comprehensive suite of support services.

Despite the fact that the design and development of new products is often more glamorous, ST Kinetics sees the TSS group as a significant part of its business going forward. Its range of through-life support services

Satisfaction Guaranteed

"In the shiprepair business, every day is a challenging day for us. We always work closely to solve problems that arise, for example, long delivery lead time of material or equipment, shortage of manpower and so on, as well as from our customer. However, nothing beats the pleasure of being able to deliver the vessel in time to our satisfied client, knowing that all our efforts have paid off."

Ten Kok Kuang
Shiprepair Manager


Mercedes Benz
零件车5

STAR Automotive Centre, which focuses on the servicing of high-end luxury cars, delivers peace of mind to car owners not only in Singapore but also in Hangzhou and Guangzhou, China.

starts from pre-acquisition studies, financing, upfront spares provisioning and equipment training to 24/7 spares support, frontline and depot levels maintenance, mid-life upgrade, equipment preservation and end-of-life disposals.

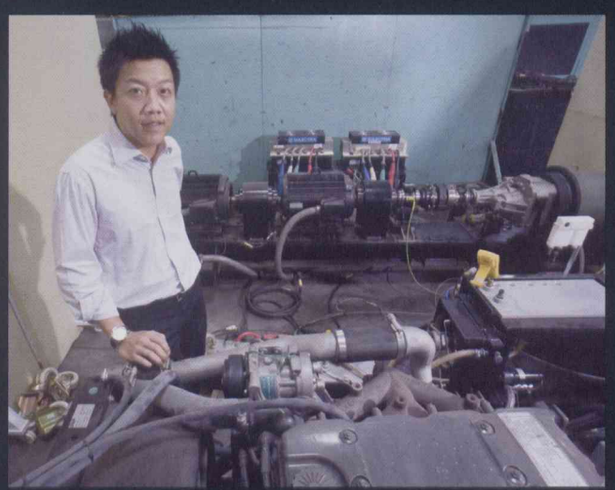
Pre-acquisition studies include competitive analysis of performance and assessment of the total cost of ownership over the systems' intended life. For customers who want to be asset-light, ST Kinetics is able to structure financing options to take the assets off their balance sheet. When the assets arrive, ST Kinetics takes care of the training and warranty of the equipment. Then, over the useful life of the systems, ST Kinetics' prime objective is to maximise the uptime of the assets, ensuring that whenever they are needed, they are there, ready to be used. To do this, ST Kinetics makes use of sophisticated spares-provisioning models and reliability-centred maintenance to pre-empt failures out in the field as much as possible.

In the area of equipment preservation, ST Kinetics is a pioneer, having amassed much experience, albeit often painful ones in the early days, in myriad ways to

An Evolving Company

"I joined ODE (96) Pte Ltd at end 1998 (before ST Kinetics was formed). Though I was a fresh graduate, I had known about ODE (96) and it being part of ST Engineering as I was an artillery officer during National Service. I was interested in artillery guns and hence working for ODE (96) was a natural choice. I had the strong impression then that the company was a very good company to join, especially for fresh graduates, in terms of further learning and building of experience. In terms of training and staff development, the company is still one of the best local companies that offer comprehensive staff development programmes. In terms of business orientation and image, that has certainly changed from a heavy military reliance towards a more commercial orientation. The change was slow but obvious; and it was strongly due to environmental, market sentiments and leadership. I think the company has slowly evolved from a metal-cutting company into more of a technology-investment company. The business focus has also increasingly shifted towards the commercial market."

Kelvin Lim Hock Seng
Assistant Vice President, Hybrid Electric Systems, Kinetics Design and Development, ST Kinetics



(L to R)

1. A mechanic doing car repairs at STAR Guangzhou.
2. ST Kinetics provides total asset management solutions from pre-acquisition consultancy, integrated logistics services and preservation to end-of-life disposal services.
3. Providing comprehensive repairs and other automotive services to the discerning public in China.

counter the hot and wet weather of the region. Towards the end of an equipment's intended life, ST Kinetics also works with the customers on ways to extend the life through upgrades and life extension programmes or help them dispose of the assets in the secondary market through its global network of contacts or through controlled demilitarisation in the case of defence articles.

"ST Kinetics is one of the most established land systems after-sales service providers in Asia. We are able to differentiate ourselves through our ability to offer total support and services. Our responsive support, fast turnaround time, quality parts and high standards of integrity set us apart from other maintenance providers out there," said Sew Chee Jhuen, President of ST Kinetics.

This same philosophy of maximising uptime for military customers extends to commercial customers, be they vehicle fleet owners or specialty vehicles and equipment users.

ST Kinetics today operates a chain of STAR Automotive Centres in Singapore and in Guangzhou and Hangzhou, China, providing comprehensive repairs and other automotive services to the discerning general public and cost-sensitive yet reliability-conscious fleet owners. According to Mr Sew, the market in Singapore is saturated with many companies providing similar services but STAR has been able to hold on to its market share due to its high standard of quality at affordable prices.

Besides STAR, ST Kinetics also operates STA Detroit Diesel-Allison (SDDA), which maintains automotive subsystems with a focus on engines and their transmissions. In addition, ST Kinetics conducts compulsory vehicle inspection services through its STA Inspections subsidiary.

"Our branding of maintenance services is one of quality and reliability. We deliver to our customers complete peace of mind when they rely on us for their maintenance needs," held Mr Sew.

Beyond Repairing Equipment

While ST Electronics' predecessor, SEEL, was set up to provide the SAF with maintenance support for its radios and electronics, ST Electronics is today a very different organisation, creating and building its

own products and solutions and providing support for them. But because of its core skills and capabilities across a broad spectrum of electronic applications, ST Electronics continues to support its sister companies when the need arises. Indeed, it still provides calibration services for instruments and gauges that are decades-old and no longer supported by their original manufacturers.

Whether in the air, at sea or on the ground, ST Engineering stands ready to give full support to customers wherever needed, whenever needed.

At ST Engineering, however, support is not enough. With its long experience in maintenance, repair and overhaul, ST Engineering is also well-positioned to help customers enhance whatever equipment or platforms they already have.

Enhancements, modifications and conversions are a natural extension of the MRO services ST Engineering provides. From making things last, ST Engineering has moved on to making them better.

"At ST Engineering, we believe that the most vital asset is our people. Nurturing and investing in our people is the key to our continued success and delivery of strategic advantage, both locally and globally."

Tan Pheng Hock,
President and CEO

(L to R)

1. STAR has maintained fleets of vehicles from commercial vehicles to minivans to trucks since 1978.
2. ST Kinetics is well-established for its maintenance support services, given its roots as a pioneer in the preservation of armoured vehicles.
3. Maximising the uptime of the customers' assets, ensuring that they are ready to be used whenever required.

Supporting Staff Growth

The high standards of quality demanded of CIS in the pioneering days of ST Engineering have set a benchmark that is continually raised. Excellence is a part of the Group's culture. But only people can deliver excellence. It is no surprise then that the Group values its people, from its top leaders to its newest recruits.

A career with ST Engineering involves continuous learning. Staff learn on the job, from special projects, coaching and mentoring, at in-house training programmes and on overseas attachments and courses. The nature of the Group's business, cutting-edge quality engineering, requires its people to keep on learning. After all, innovation is not just about technology; it comes from the minds that drive it.

Staff create their own development plan and choose from a variety of learning solutions and methods. These training "road maps" and programme choices are created online through the Leadership Enhancement Portal (LEAP). The Group keeps on the lookout for new courses and programmes that will enhance the capabilities of its staff.

The efforts, whether at work or in learning, are recognised through performance-based pay and bonuses.

The Group also hopes to help nurture young people with top academic results and outstanding co-curricular activities. It offers scholarships for university studies to increase the pool of talent the Group can draw on in years to come. Some of the top schools include Harvard University, University of Cambridge, Stanford University, Massachusetts Institute of Technology and University of California, Berkeley. The scholarships are generous, with tuition fees, living expenses, book and travel allowances – not to mention a guaranteed job at the end of the scholar's studies.

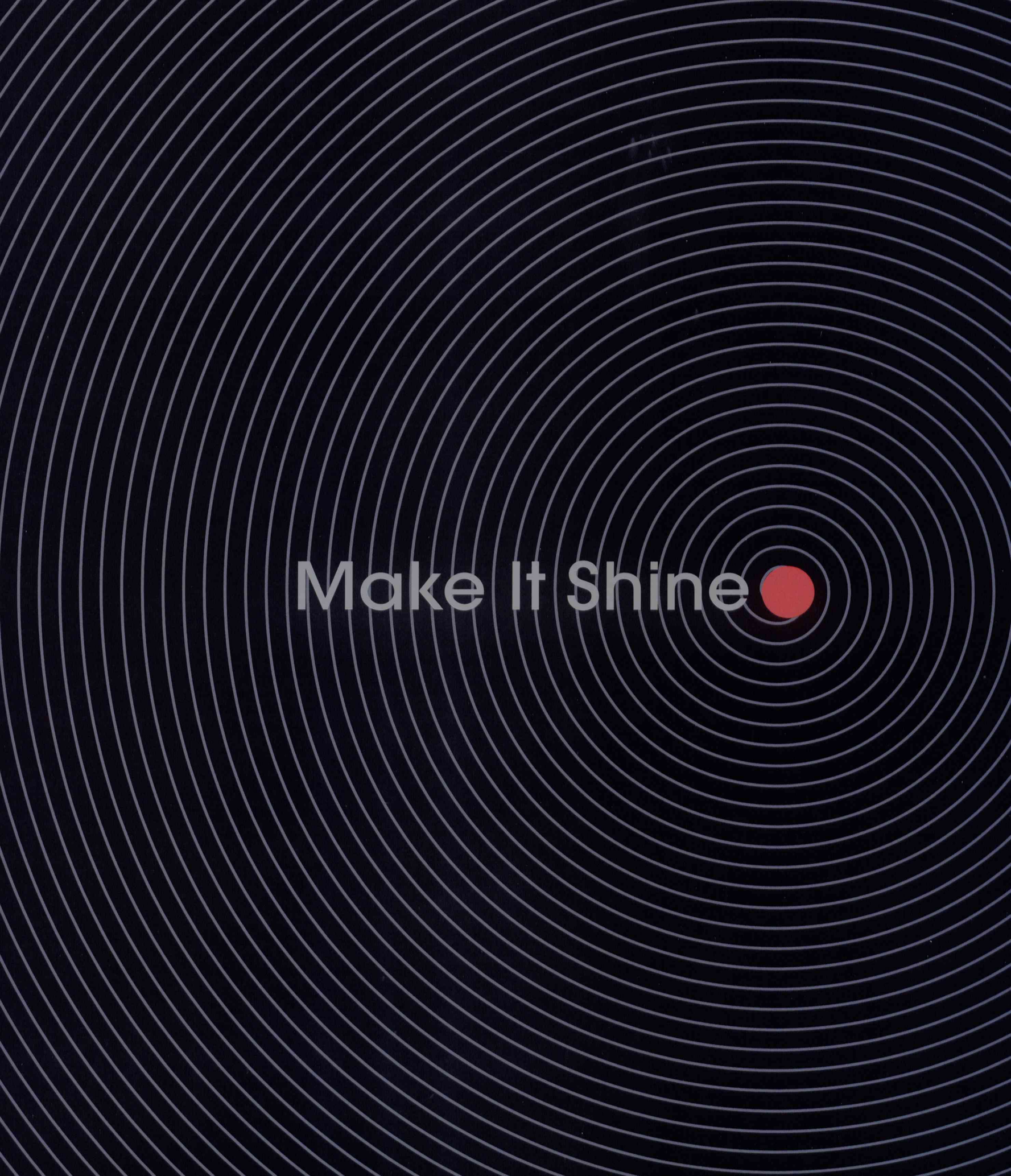
From Factory Hand to Manager

Ng Loon Ji has been with ST Engineering for 39 years and is one of the longest-serving staff. Her rise from factory worker to Manager, Chemical, Microbiological and Environmental Division, Singapore Test Services, ST Kinetics, is the story of how one person dared to think big and did all she could to make that dream come true.

"In 1968, I joined CIS and was deployed to work in the Small Arms Ammunition plant (case section) as a factory worker cum machine operator running the 'annealing machine'. In 1972, I asked for a transfer to work as a laboratory assistant in the chemistry laboratory. I had always liked analytical work and was very happy that I could contribute there. Subsequently, through the years, I was promoted to senior technician, supervisor and senior supervisor. In 1988, I took up a part-time diploma course in Chemical Process Technology with Singapore Polytechnic. In 1992, I was redesignated as a chemist and in due course promoted to senior chemist and manager."

In 2000, she took up a part-time Masters degree course in Environmental Management Studies with the University of Adelaide and topped her course.

"I owe my success to my colleagues who have helped me in one way or another throughout my career – my colleagues in SAA, foreman Woo Sao Tim, C.C. Cheong, co-workers Nancy Lok and Ng Ah Hoi. I am indebted to Manager Tjua Jang Long, who encouraged and supported me in taking up the Chemical Process Technology course. I am indebted to Yvonne Yong from Human Resource, who convinced the senior management to sponsor my Masters degree course, without which I would not have come this far."


Make It Shine

ST Engineering could have stayed an MRO company, but as President of Special Projects Wu Tzu Chien put it, it was itching to do more. Modifications and conversions were really a natural extension of ST Engineering's capabilities. It had the equipment, it had the people. All it needed was an opportunity.

ST Kinetics had its first real modification triumph with the AMX-13 tank. The aging light tank, bought second-hand, was given a new engine, suspension and an automatic transmission. Practically only the hull and the already accurate gun were not changed. Renamed the AMX-13 SM1, this hardy little tank still provides a heavy punch for Singapore's armoured forces.

ST Kinetics achieved yet another significant milestone when it won the contract amidst keen competition to upgrade the M113 for the SAF in 1993, as it moved into systems integration of various weapons and subsystems onto an armour vehicle platform. As the appointed prime contractor, it was responsible for integrating the Overhead Weapon System (OWS) with 25mm cannon, CIS 40/50 Cupola (the first

CHAPTER THREE

(L to R)

1. The AMX-13 SM1 still provides a heavy punch for Singapore's armoured regiments.
2. Ships can be enhanced, made larger or converted for entirely different uses.
3. Retrofitting the AMX-13 tank.

twin weapon station developed by CIS), M113A2 Mk1 mobility kits and many other subsystems and on-vehicle-material (OVM) to enhance the operational capability of the M113. The upgraded M113 went on to form the backbone of the SAF Armour for many years and is still in active service.

With that experience, ST Kinetics moved on to the creation of new vehicles, like the Bionix, Bronco, Terrex and a whole slew of specialty vehicles through its acquired companies. New products, however, can always be improved and modified. The Bionix, for example, has many variants dedicated to meet the specific needs of customers, and has been upgraded to Bionix II to meet the new requirements of a digital battlefield.

Right On Track

With more wrench time with the A-vehicle fleet, SAE grew more ambitious and began taking up the upgrading and modification of combat vehicles such as tanks, armoured personnel carriers, weapons systems carriers and command posts. One early success was the retrofitting of the French-made AMX-13 light tank with a diesel engine and automatic transmission. The AMX-13 model is half a century old, but is still running strong, thanks to SAE's work on it. The AMX-13 retrofitting programme was the very first locally modified product that placed SAE on the world map for its capability in automotive engineering. It competed in many overseas competitive trials and always scored exceptionally well in performance and reliability. It was the most complete retrofit engineering package for this tank.

"The AMX-13 is a very compact vehicle," Mr Wu said, adding that its small size made modifications very challenging. "We replaced the very old, no longer supportable engine with a more powerful and reliable one. The non-synchromesh manual gearbox was replaced with a fully automatic transmission integrated with the engine for the most optimal performance. The specially designed suspension system that replaced the old system is still one of the best in ride comfort. We even upgraded all the 'electrics' in the vehicle. In fact, we only kept the hull and the gun turret system. The hull had to be strengthened for the improved performance. The gun turret system was kept because it was very accurate to begin with, and it was further enhanced with a new fire control system. For completeness, even its ammunition was upgraded and this was done by CIS. Without any doubt, the retrofitted AMX-13 SM1 (ST Kinetics' upgraded AMX-13) is a much better performer than its original was ever dreamt to be."

While the modification was a significant achievement in itself, much more crucial was the confidence it gave the company. The AMX-13 SM1 demonstrated its capability and gave it the confidence to go on to more challenging and complex products, like the Bionix Infantry Fighting Vehicle.

Starting with just retrofitting the AMX-13, ST Kinetics now designs, builds and maintains new armoured vehicles including the Bionix Infantry Fighting Vehicle.

To Survive, Be Proactive!

"There have been endless learning opportunities since I joined in 2004. The experience and knowledge gained are both beneficial to my personal development and to the growth of the organisation. Every day is a challenge and the pace of work is fast. Thinking out of the box is a basic rule of survival in this fast-changing market and the company certainly has been proactive in making the necessary arrangements to prepare its existing workforce for it. Working in a shipyard gives one an opportunity to work and interact with various departments at all levels."

Lim Wei Liang
Department Head, Diesel, ST Marine

Big-scale Conversion

ST Marine was created from the outset to make new products, but unlike its sister companies, the knowhow for building ships (and converting them) was already available.

Because of their scale, ship modifications can take many forms – it is not unlike renovating a large building. Marine engineers have far more leeway with changes to a ship than engineers for an aircraft or a land vehicle. With their core skills in repair and newbuilding, ST Marine can handle just about anything a customer wants changed. There are no fixed solutions – the possibilities are vast, given ST Marine's capabilities.

Tay Lay San, Senior Manager (Commercial) at Tuas Yard, emphasised that all conversions are challenging and each one is different – there is no "standard" conversion.

"Owners use conversion as a way of reducing the amount of time needed for them to get a vessel of roughly the same size, but with a totally different function. It is not necessarily cheaper to convert a ship than to build a new one.

(L to R)
1, 2. *Aquila Explorer*, a platform supply vessel, before and after conversion into a seismic vessel.
3, 4. *BGP Pioneer*, a fishing trawler, before and after conversion into a seismic research vessel.
5. Jumboisation of a livestock carrier, lengthened from 99.8m to 122.08m.

"They are also higher in value than normal repairs," he said. "Conversions require different skill sets. There is more engineering and more detailed planning and management."

Conversions usually involve changing the vessel's dimensions (usually its length) and function. The *BGP Pioneer*, for example, was a fishing trawler that was converted into a high-tech seismic vessel. In order to perform its new role, the vessel also had to have its hull widened.

Making a vessel larger, or "jumboisation" is a challenging process. Phua Siang Ling, Senior Manager (Hull), described the process of his first jumboisation project when he was an Engineer. He has a vivid recollection of that experience.

"I still remember clearly the first jumboisation I worked on. It was on a dredger which was supposed to be extended by another 20 metres. First, we needed to study in detail how to split the vessel into two portions, and the method of shifting the forward portion forward so that the new 'vessel body' could be inserted in between these two portions. Planning was absolutely crucial, but execution of the plan was even more challenging." For Mr Phua and his colleagues, every ship is an opportunity to learn something new.

"We've converted a car carrier to a livestock carrier," said Mr Tay. "That's a very different function, even though they're both cargo. Cars are all mechanical – you just load the vessel, secure and go. But for livestock, your cargo is alive – say huge cattle or sheep. They need water, food, ventilation – things that cars don't need!"

Reducing crew size is never the main objective of a conversion, Mr Tay added, but it was a consideration in design. At the end of a conversion, the owner gets a practically new ship.

Conversion, for ST Marine, is more than a service for a client. Like the other business units of ST Engineering, ST Marine is always looking for a way to do things better and more efficiently, for example, making the best use of the space in its two yards.

"We try to optimise the space we have in the yards and try to improve efficiency," said Mr Tay. "You look at the areas, you reorganise the space, rethink the work

ST Aerospace offers value-added services in aircraft modifications, customised upgrade solutions and a host of engineering and support services. Here, heavy maintenance work is being performed in one of MAE's hangars.

(L to R)
1, 2, 3. Aircraft modifications include maintenance of cabin insulation and upholstery, and even the replacement of the J65 engine to the higher performance F404 engine on the RSAF's A-4 fleet.

flows. We have a lot of very experienced staff here. They know what they want. They share ideas with the younger engineers and we also listen to feedback from owners.

"What will probably happen is that we will buy yards or have new joint-venture yards or even greenfield yards. Nothing's decided yet; we're still exploring options."

Second Wing

New aircraft are very, very expensive. Because of safety regulations, aircraft also tend to be kept in better condition than, say, cars or ships. With their much longer operational lifespan, aircraft can be sold to other operators when its first owner buys new aircraft. Singapore Airlines, for example, has a policy of keeping a "young" fleet, and the market for second-hand aircraft is reasonably large.

A new owner, however, will need to remodel the interior of the aircraft and change its livery. In more extreme cases, the new owner might have a different purpose for the aircraft and thus need to modify it accordingly. Modifications range from making an existing aircraft perform better or more safely, to changing its interior entirely, such as when a passenger aircraft has to be converted into a freighter.

Aircraft types that ST Aerospace is able to conduct modifications for are the Airbus as well as the Boeing and McDonnell Douglas range of aircraft. ST Aerospace's facilities in Asia, Europe and the United States are well-equipped to handle modifications for the A320, including wing spar modifications and fuel tank bonding, cockpit anti-intrusion and penetration resistance door modifications, Enhanced Ground Proximity Warning System (EGPWS), camera and video surveillance and avionics modifications.

For ST Aerospace, the early experience of rebuilding A-4s from a mixture of old and new parts helped its people gain the confidence to handle the conversions of A-4s into later local variants. This early comprehensive support covering airframe, engine, components, engineering and material services was part of the strategic partnership with the RSAF.

That, coupled with its later experience in MRO for commercial aircraft, paved the way for ST Aerospace to enter the commercial aircraft modification market.

ST Aerospace upgraded the avionics of the A-4 with a state-of-the-art Weapons Delivery and Navigation System.

Super Skyhawk!

While the A-4 Skyhawk was on the whole a good aircraft, it was underpowered. Engine spares were also difficult to obtain.

In 1988, MINDEF decided to keep the A-4, but to replace the Curtiss Wright engine with the General Electric F404-GE-100D, a non-afterburning engine. Engineers from SAMCO, MINDEF and the RSAF got together and worked out the upgrade details at SAMCO.

Major structural changes had to be made to the A-4 frame to take the more powerful engine. The results were worth all these changes. The aircraft, renamed A-4SU Super Skyhawk, could now fly faster and could carry more.

Foo Siang Chee, Assistant Principal Engineer (SM), considered the replacement of the A-4C engine, which turned the humble Skyhawk into Super Skyhawks, his favourite project. He also listed the initial A-4C refurbishment programme and the conversion programme that turned the A-4C into a twin-seater as the most memorable projects.

"Those were firsts for the company. Each time we broke new ground," he said.

The Skyhawks are now only in service in France. But this first modification project laid the groundwork for future work by ST Aerospace not just on military aircraft, but also commercial aircraft conversion.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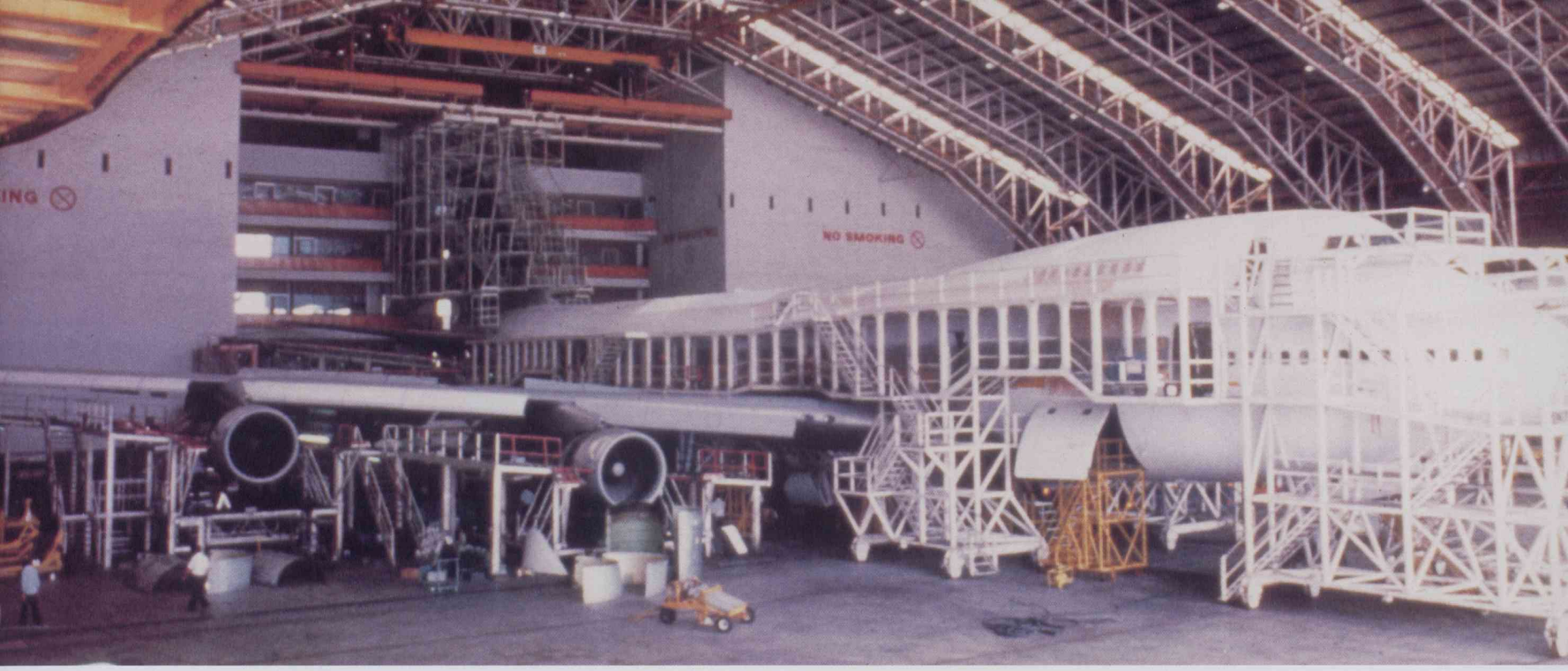


(Above)
ST Aerospace's focus on bringing value to customers also emanates from a commitment to enhance the performance of the aircraft by improving the maintenance lifecycle. It has set industry records for turnaround times on programmes like the Boeing 747 Section 41 modification, and the DC-10 and MD-11 freighter conversions.

(Opposite)
To improve its quality standards, turnaround time and service support, ST Aerospace builds upon the proficiencies of its specialist subsidiaries and complements them with new capabilities to ensure that customers' aviation maintenance and engineering needs are more than adequately met.

Ho Yuen Sang, Deputy President of ST Aerospace, said the decision made by Quek Poh Huat, then President of ST Aerospace, to take on commercial work was a very significant strategic decision.

"Today, if we were not doing commercial work, a significant part of our business would not be there. That was our first strategic decision. The next was the decision to go overseas. That was quite daring. Our commercial business was only a year old when we decided on a brownfield development in Mobile, Alabama. We chose the United States because it is a dominant force in the industry – it is the biggest market. The catchment area for commercial aircraft is the biggest and most accessible there. The language was also not a problem and we got a good deal."

Those decisions have helped make ST Aerospace the top revenue generator of ST Engineering's four sectors. The success of MAE in Mobile also helped overcome the mental block of working overseas – ST Engineering was no longer a company with facilities only in Singapore.

Section 41

ST Aerospace's confidence in its ability to perform major structure work was demonstrated by SASCO performing the Section 41 modification on the very first aircraft it inducted. Section 41 is the forward portion of a Boeing-made aircraft, from nose to aft of the cockpit. For the Boeing 747, because of its "hump", its Section 41 is comparatively large. Over the years, the materials used in the Section 41 had started to crack due to fatigue and stress. Boeing provided a kit to modify the section, while airlines paid for the labour.

At first, like most other companies, ST Aerospace took between 50 and 55 days to complete the job. But they got better and faster and were soon able to finish the job in 41 to 42 days – a significant saving in time. Ultimately, this translated into financial savings for airlines as the aircraft could return to service sooner. And for an operator with a large fleet of Boeing 747s, this was a very important point.

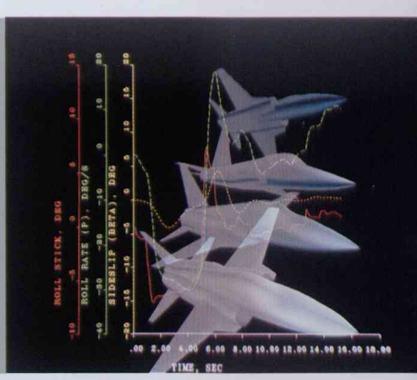
"So it wasn't just strategy," Mr Ho said. "You have to be able to execute it well too!"

Strong Team Spirit

Hui Ming, Principal Technician for SASCO, said, "If you treat people well, they will treat you well too. There is a strong team spirit and we all work towards one goal – to help the company make money so we can get some too! If you don't, your job is not secure.

"This is a job I've enjoyed very much. I joined as a senior technician, but am now a lead man. There is still room to grow, to improve, especially as the company keeps expanding. So far, this has been the best work situation I've had."

(L to R)
1, 2. ST Aerospace's Engineering & Development capability harnesses state-of-the-art technology to provide customised aircraft upgrade solutions while also delivering cost-effective aircraft modification solutions for customers.

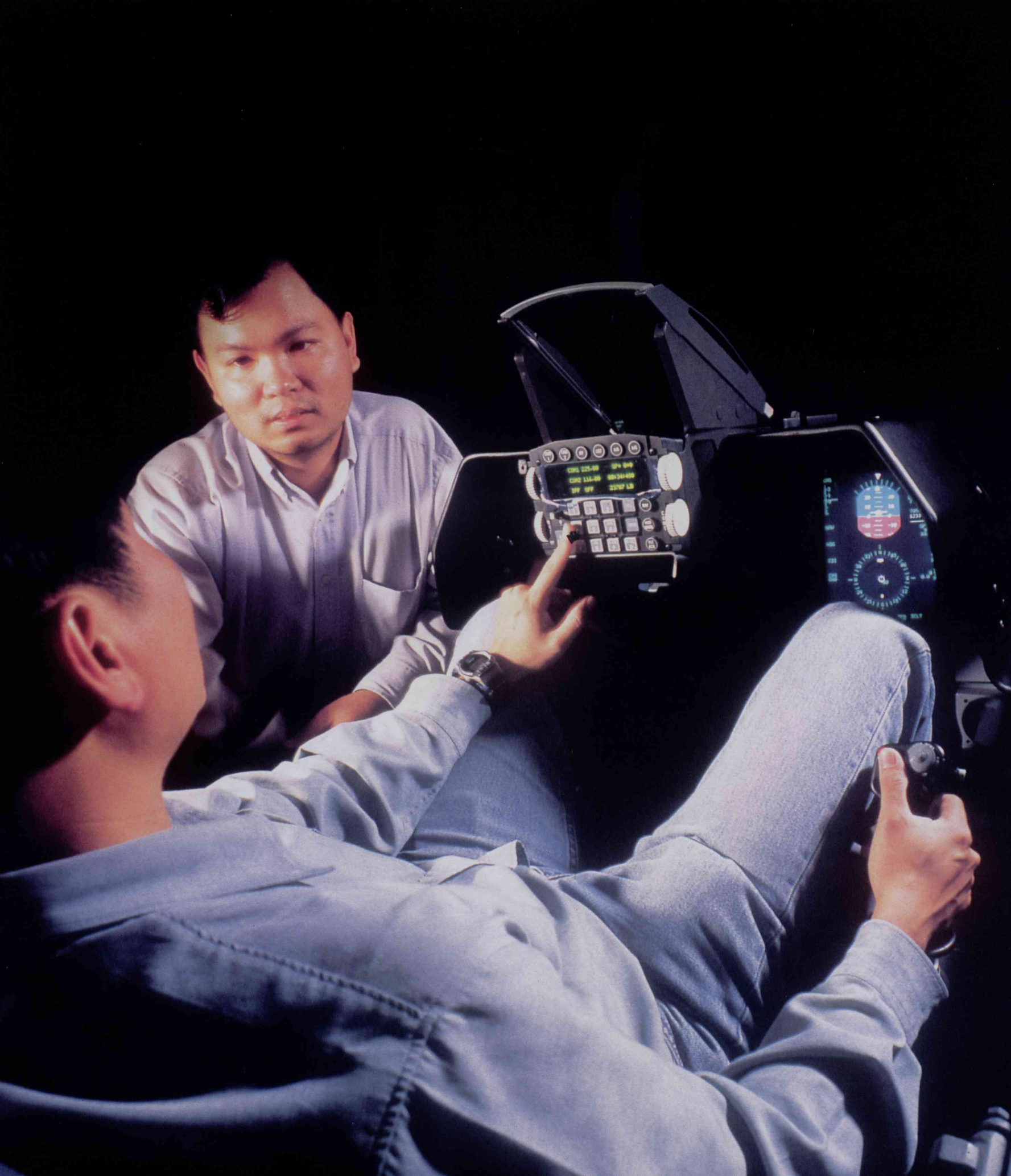


Airliner to Freighter

Eventually, SASCO and MAE began providing the labour for conversions of passenger aircraft into freighters. MAE started with the Boeing 727s, followed by the Boeing 757s, while SASCO took on the DC-10, MD-11 and soon the Boeing 767-300.

ST Aerospace works with the Boeing Company to handle its modifications for Boeing aircraft. The Boeing 757-200SF freighter conversion, for example, is based on licensed data from Boeing's original production passenger and freighter aircraft as well as ST Aerospace's proprietary design used on proven freighter conversion since 2001.

Today, ST Aerospace is also able to convert a Boeing 757 using its own supplemental-type certificate. The company provides the engineering development, conversion kit manufacturing, certification, in-service experience and full product support to make the conversions successful. ST Aerospace is a one-stop centre. But it also aspires to be a lifetime partner.



The first Boeing 757 aircraft for the Royal New Zealand Air Force undergoes freighter conversion which would allow for a combination of configurations.

Partnering Boeing in Freighter Conversion

Boeing has recently added the B767-300 to ST Aerospace's conversion repertoire. With ST Aerospace as one of Boeing's top suppliers, this should be no surprise.

"Boeing chose to work with ST Aerospace because they had built up a reputation over time," said Dr Marco Cavazzoni, Vice-President of Boeing's Freighter Conversion Programme.

"They had demonstrated performance in conversion and both our companies share the same values, like integrity, for example. We are aligned here. How they work and how they do business to have a long-term relationship with a long-term supplier-partner is what helped convince Boeing.

"They are honest and clear in their communications. There are issues that crop up during work, of course, but they are able to address these in a respectful, rational way. Anything we've brought up has been resolved.

"They share the same perspective – everything starts and ends with the customer. It is the same focus.

"Boeing does build freighters on our production line. In the case of conversions, it is to establish an extended global enterprise, so we need supplier-partners like ST Aerospace with core competencies. Certain things, they do better than we do.

"They had the MAE facility – it was a first. They didn't do conversions there, but the type of work let us make the assumption that they had the core competencies to do it. A freighter conversion pulls together all these core competencies.

"They provide a very good integrated package for the B757-200. They do the engineering, the parts procurement, the certification. FedEx Express is their first big customer for this aircraft.

"As for their quality of work – I've had customers tell me: 'Ask SASCO. I put an aircraft there and I don't have to worry.' SASCO doing conversion is a winning combination, they've told us.

Dr Marco Cavazzoni, Vice President of Boeing's Freighter Conversion Programme, with Tay Kok Khiang, President of ST Aerospace.

It is what we want our customers to feel – 'no worries'.

"Freighter conversion is a very complex job. An aircraft comes in, they take paint off, put it on a jack, physically rebuild it from inside out. All the structures, all the floors come out. They strengthen and replace the fuselage, electricals, air controls. When they disconnect the nose, there are hundreds of miles of wiring to replace and reroute. It is astounding. They basically rebuild the aircraft. And at the end of it, it looks like a brand new production freighter. It takes about four months to do.

"How do we identify a top supplier? It's differentiation. At the end of the day, quality is first. Quality of everything, from the product to the experience to the customer relationship to the process. It is also how they meet commitments to schedule, quality and finance.

"It is expected of everyone, true, but can people achieve that? Let's face it, there are some suppliers that perform better than others. SASCO has consistently done this. We look for validity (their quality) and reliability (the repeatability of that performance). Tough criteria to meet, and that is what separates SASCO from the others. Reputation is something you can build for years and then stumble on because of a single occurrence.

"We have different models of aircraft, way beyond the B767. As opportunities come up with different platforms, if our relationship stays strong and ST Aerospace maintains its quality, we'll work together. Only time will tell. But so far, it has been really positive."

F-5 Project: Initiative and Dedication on the Ground

What distinguishes ST Aerospace personnel is their initiative and dedication to their jobs. Even when far away from home and familiar support and equipment, ST Aerospace's men will do what it takes to get the job done right.

"The installation of video camera on a foreign air force's F-5 aircraft was one of the most interesting projects that I worked on," said Ler Hock Seng, Assistant Principal Engineer, Engine Development Centre.

"This project involved 30 aircraft and the whole programme was divided into three phases, namely prototype phase, production phase 1 and production phase 2. The works were carried out from July 1985 till February 1986. The team consisted of one engineer, two structural technicians, and two avionics technicians. I was one of the avionics technicians, and also appointed as lead man in charge of the production team.

"The installation works on the first two prototype aircraft were smooth and without any problem. Upon successful completion of the prototype aircraft, we were given the production phase 1 go-ahead.

"Everything went smoothly until the seventh and eighth aircraft, when the test equipment broke down. After an internal discussion, we decided to improvise by requesting a black-and-white TV from the squadron which we used as a substitute display for the test equipment. We bought some TV cables and connectors, and then modified the test equipment so that it was able to display the data on the TV. With the improvised test equipment, we were able to proceed with the testing for the remaining aircraft.

"We also converted our hotel room into a workshop so that we could do system calibration in the hotel room at night. This is how we worked in the old days; we had to use a lot of initiative as there was no one around to guide us. Although the work was tough, there was a lot of self-actualisation and satisfaction when the job was finished."

ST Aerospace offers one of the best F-5 upgrades in the world. This picture shows an upgraded F-5 being serviced in its Paya Lebar facilities.

(L to R)
1, 2. ST Aerospace also provides convenient one-stop maintenance services including avionics and structural and systems upgrade for aircraft including F-16 Falcon, F-5 Tiger, A-4 Skyhawk, C-130 Hercules, KC-135 and the Super Puma helicopter.

Eyes, Teeth and Claws – Enhancing Combat Aircraft

Starting with the RSAF's A-4SU Super Skyhawk, ST Aerospace has performed and delivered some of the world's most technologically advanced avionics upgrade solutions for fighters and trainers. It provides modular upgrade solutions designed to enhance the performance of combat aircraft. Solutions are updated with evolving technologies from ST Aerospace's in-house Engineering & Development Centre (EDC). These solutions are flexible and can be customised to specific needs, while offering a wide selection of subsystems from authorised suppliers worldwide.

With ST Aerospace, any upgrade comes with total upgrade support – making their fighter and lead-in trainer upgrade solutions cost-effective and, more importantly, enhancing the operational capabilities of a fighter fleet.

Make Them Meaner

ST Aerospace's experience with modifying military aircraft has led to such services extended to a wider range of aircraft. It can convert aircraft like the C-130 for different roles, upgrade avionics systems of jet fighters or simply arm a helicopter with door guns to enhance its survivability in combat.

The Lockheed Hercules C-130 can be converted for many roles, from tanker to airborne medical centre. ST Aerospace can handle all the conversions as well as maintain the C-130 for its entire lifetime.

Like the A-4, the later aircraft bought by the RSAF were also modified or upgraded. The F-5 modification package provided by ST Aerospace is one of the finest in the world. There are also upgrades for the F-16, proving ST Aerospace's ability to integrate the most up-to-date systems into one of the most advanced fighter aircraft in the world today.

The Twilight Zone

Repairs were an important first step for all of ST Engineering's companies. ST Kinetics began by repairing the SAF's vehicles. ST Aerospace kept the air force in the air. ST Electronics ensured all the SAF's gauges, instruments and radios were in good order. Although ST Marine started by building the RSN's vessels, repairs were necessary later.

(L to R)
1. ST Electronics' home base at Ang Mo Kio.
2. Calibration services for equipment and info-security encryption solutions are just two of ST Electronics' many capabilities.

As capabilities grew, upgrades naturally followed. This was spurred by the increasing and changing needs of their primary client, the SAF, as well as an increasing number of commercial clients.

The actual creation of new products, however, requires more than technological knowhow and long experience. To create new products that will go one step better than what is already available, an organisation needs a "dream team" – not just a group of the best minds, but a group that is passionate about what they are doing, and given the opportunity to do great things.

Between modification and the creation of new products, there is an interesting "twilight zone". Once handled by the Defence Science and Technology Agency (DSTA), integration is now confidently handled in-house by ST Engineering. In this mysterious realm, ST Engineering's men and women bring together systems they may not have created into applications and combinations that the systems' creators might not have anticipated. ST Engineering's goal is to make all those systems work together – and in the process, create synergy and value.

The fixed wing and rotary wing upgrades are examples of how disparate subsystems can be combined into a whole that will help a combat pilot fight better and perhaps increase his odds of survival. On board ships, information systems, control systems and weapon systems need to work together properly for combat effectiveness. And the increasingly sophisticated information and defence systems of ground combat systems need to be integrated too.

In this realm of the intangible, the capabilities of ST Electronics come to the fore.

(Opposite, below)
Simulation technology is an effective way of training without the high running cost of actual operational equipment.

Enhancing Management Services

While ST Electronics began as a company servicing electronics equipment, a desire to grow saw it develop into a full-fledged system house, with a wide range of innovative system products and solutions. Investing in in-house R&D and creating its own product and service offerings, ST Electronics today has under its brand, a collection of innovative products such as Metro systems, Fleet Management System, Satellite VSAT, Supernet radio gateway and IP switches and

Learn on the Job

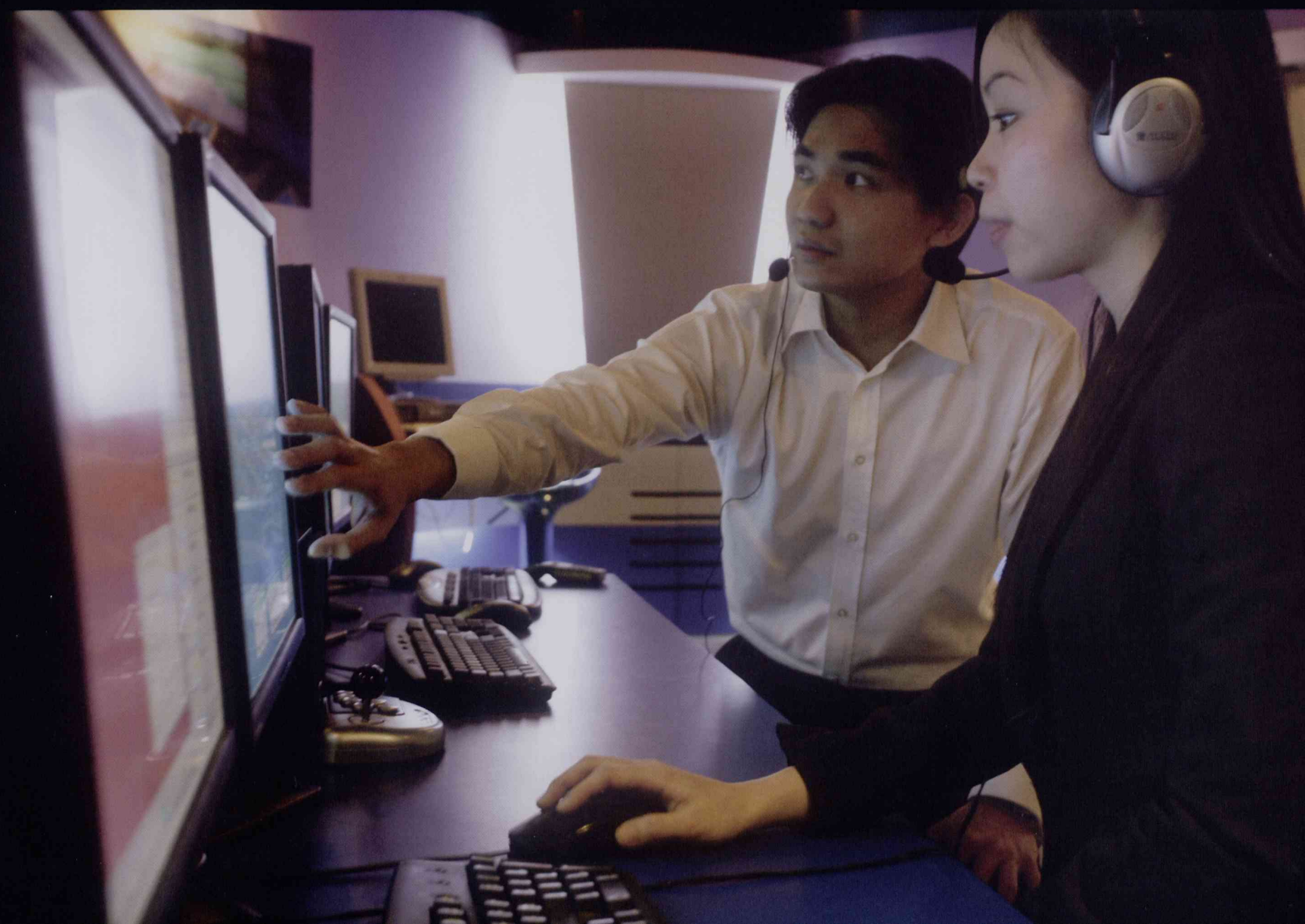
"I joined ST Electronics in July 2004 right after graduation, having taken a Singapore Technologies scholarship for my university education. At the time, I felt that it was a large and dynamic organisation where I could find some niche where my interests and skills would fit in.

"I have been with the organisation for about three years now – specifically, with ST Electronics (Info-Comm Systems). In the beginning, my work was close to my area of study – image processing. Gradually, however, I was assigned to other projects where it became a matter of fitting my interests and skills to the requirement rather than the other way around. This has been both a learning experience and a challenge for me, but I must say that it provoked me to leave my comfort zone and gain new skills on the job.

"Over my time with the company, through colleagues' sharing and personal experience, I have gained more insight into the organisation, which has been evolving. For example, we are in the midst of reaching out to overseas markets. For me, a clear sign of this was our name change from CET to ST Electronics (Info-Comm Systems), a stronger and more widely known brand name overseas. Although this had no impact on my personal work scope (beyond changing all my name cards), many of my colleagues have been on overseas sales trips, or have done overseas projects, or prepared bids for overseas tenders.

"I think the most important skill I have developed with ST Electronics is learning on the job. The exposure to foreign domains and technical fields, especially under time pressure, is a big source of stress but it also forces me to focus and selectively learn what I need to get something done."

Fiona Loke (second from left)
Engineer, ST Electronics (Info-Comm Systems)



(Above)
A ship handling simulation solution allows ship pilots to train before taking the vessel to sea.

DigiSAFE info-security systems. It has created intelligent systems or solutions that are built around core in-house intellectual properties. The company has kept pace with its customers' priorities in outsourcing less mission-critical services.

With systems and services, ST Electronics progressed into managed services, providing total services to customers' system support requirements, often on a 24/7 basis. With the global trend for governments and corporations to outsource their ICT/system support to professional vendors while focusing on their own core business, ST Electronics management has set a clear direction towards building a managed services business.

Over the years, ST Electronics has successfully secured a number of managed services projects from the Government. ST Electronics has built for the Ministry of Home Affairs, a command, control and communication network that links all voice and data networks of the Home Team's individual command centres with police stations/posts, hospitals and fire stations located country-wide. This system allows the Home Team – comprising the Singapore Police Force, Singapore Civil Defence Force and Central Narcotics Bureau – to work cohesively as one integrated entity to safeguard the security of the nation. With this, different communication systems operate seamlessly with one another, allowing the Home Team to inter-operate and communicate effectively and efficiently.

ST Electronics also provides managed services and e-Government solutions to its commercial and defence customers. These include 24/7 support services for some of the systems that have been set up by the company for its customers. It provides infrastructure, services and communication solutions to public sector users in Singapore, Botswana, Maldives, Kazakhstan, and more.

For service support outsourcing, ST Electronics has established a subsidiary company with 350 staff to focus on this growing business. This is the first privatised, home-grown shared services organisation based in Singapore, and it has a fully operational centre delivering a complete suite of human resource, finance and administrative services. Its delivery model leverages on integrated e-enabled processes which provide customers with one-touch convenience,

(Above, L to R)

1. Visualisation graphics and computer simulation assist in training.
2. Battlefield management solutions bring real-time situational information in combat.
3. e-Government and managed services allow customers to better utilise their resources.
4. VSAT satellite communications solutions are effective for disaster recovery.

reliable support and expertise to operationalise policies across big populations.

ST Electronics' services business got a big boost when it was awarded a large project by MINDEF valued at over S$250 million in 2007. Under this outsourcing project, ST Electronics provides shared services to over 350,000 active personnel, regulars and NSmen of the SAF. These services include human resource and finance services, as well as National Service administrative services.

The RSN has looked to ST Electronics for its Integrated Workforce requirements. The company now provides the RSN with a skilled workforce and an experienced management team that is qualified and competent to undertake and operate maintenance, management and engineering services for the RSN. ST Electronics' Integrated Workforce has been able to retain the core competencies needed to support the RSN's combat electronics systems through staff training and recruiting ex-RSN specialists.

Lee Fook Sun, President of Defence Business and Deputy President (Operations) of ST Electronics, pointed out that "In our quest to build a company that lasts, we realised that firstly it makes good business sense to contribute to building a nation that lasts. ST Electronics has been a key provider of products, systems and solutions to our defence, security and government customers. Undoubtedly, we are in a unique position to synergise and value-add what we are already offering by adding e-Government services and 24/7 support services. This is yet another way through which we can help to build and operate a modern and seamless information infrastructure that will contribute to our nation's continued survival, security and success."

How Big Do You Need It?

Electronics touch almost every part of our lives. The traffic monitoring system, flight information at airports, global positioning that allows us to call a taxi, wireless communications, convenient library book drop-off at any location, technologies that ensure that the MRT system runs smoothly. Take away the magic of electronics and our lives would suddenly be very, very different – and perhaps significantly less convenient and comfortable.

ST Electronics enables rail systems to run on time safely and smoothly through efficient electronics rail command systems. Commuters on Beijing's MRT system will soon be monitored by the world's largest Traffic Command Centre.

(L to R)

1. Simulators enhance training of train drivers.
2. Facilities adopt intelligent monitoring systems for better protection.
3. Calling a cab is convenient and fast with iCab solutions.
4. Parking made easy.
5. Comprehensive traffic monitoring systems keep traffic smooth-flowing and pedestrians safe.
6. Simulation systems train air traffic controllers to handle various situations, emergencies and weather conditions.

In 1997, ST Electronics acquired the businesses of Agilis Communication Technologies Pte Ltd, CET Technologies Pte Ltd (then known as CEI Technologies Pte Ltd), Singapore Engineering Software Pte Ltd and ST Training & Simulation Pte Ltd (then known as ST Simulation Systems Pte Ltd). These companies have since been renamed ST Electronics (Satcom & Sensor Systems) Pte Ltd, ST Electronics (Info-Comm Systems) Pte Ltd, ST Electronics (Info-Software Systems) Pte Ltd and ST Electronics (Training & Simulation Systems) Pte Ltd respectively. In addition, ST Electronics itself came under the amalgamated ST Engineering.

With these acquisitions, ST Electronics expanded its capabilities to include satellite communications, infocommunications technologies, information technology and software development as well as simulation and training systems. All are capabilities to provide solutions that pervade our lives every day.

Precisely because they are so much a part of modern life, we tend not to notice the electronics working in the background – and the people who design them, install them and integrate them to make everything work properly for us.

ST Electronic's first foray into integrating large systems was in Changi Airport, which opened in 1981. One of the largest buildings at the time, Changi Airport needed a very large and complex building information system.

Today, Raffles City, NTUC Income Building and Capital Towers are just some of the buildings that ST Electronics has designed and implemented integrated systems for. The current tallest building in China, the 88-storey Jin Mao Building in Shanghai, runs on a system put together for it by ST Electronics.

Building control systems are a kind of command and control system. They regulate heating, vents, lights, power and maintenance routines. And in today's post-9/11 world, security management has become even more important. With ST Electronics' background in defence, it certainly has enough knowledge and skills and has begun to handle this subset of the business too.

ST Electronics pioneered solutions for building automation and controls. It provides the intelligence that allows various security, maintenance, electronics and communications systems to work together seamlessly. By integrating computer, communication

and control technologies, it offers integrated solutions to address the needs of customers in commercial, residential and education markets.

On the Right Track

ST Electronics is today a leader in electronics systems and information technology, and is the largest infocommunications technologies (ICT) player in Singapore for e-Government and public infrastructure, intelligent transportation and digital media and animation. It is a little-known fact that ST Electronics, together with an overseas partner, is responsible for the communications and control system of much of Singapore's MRT network.

Train control centres need to be manned continuously, and operators vary in degree of skills and expertise. To help them, all the operational rules and scenarios are programmed into the system and every action taken is logged into the system. It prompts the operator, but allows him or her to make the final decision. ST Electronics provides turnkey control systems and is one of the biggest regional players in rail system projects today.

For Singapore's MRT, ST Electronics developed the software and hardware for systems such as the automated fare collection. When the group took on MRT projects in Taiwan and China, it brought along its experience and tried-and-tested software and hardware designs. With China's on-going modernising programme, it will be quite some time before there are MRT networks in every Chinese city. And Chinese local governments have noticed the quality of ST Electronics' work. Beyond East Asia, ST Electronics has also worked on Manila's Line 2 LRT system, an MRT system in Bangkok, and is providing systems for Turkey's MRT as well.

ST Electronics tries to localise some of its production in order to lower the cost of production and provide work for the local business community.

Special Systems

Besides large buildings and MRT systems, there are customers with smaller facilities that need unique solutions. Parking is an issue in Singapore and many buildings, like the Esplanade, Bugis Junction, Lot 1, IMM, Bukit Panjang Plaza, Tampines Mall, Funan Mall,


SMRT

(Above, L to R)

1. Singapore's North-East Line's MRT Operations Command Centre.
2. Agilis Maritime VSAT, the smallest 1.2m C-band antenna in the world.
3. The Infrared Fever Screening System helped screen travellers for fever during the SARS crisis in 2003.
4. Borrowing and returning books from libraries is made easier with the library management system.

(Opposite)

Most of the electronics systems of Singapore's MRT is supported by ST Electronics' expertise.

Plaza Singapura and Suntec City, as well as buildings in Indonesia, Malaysia and Dubai, have ST Electronics integrated systems.

ST Electronics also provides special systems for prison security, and created a special climate control system for the Liao Ning Shanghai Museum to protect and preserve its priceless exhibits.

In Hong Kong, the Hong Kong Fire Department uses FLAMES – or Fire Location And Management of Emergency System. In the densely populated residential areas, getting to a fire fast is critical. FLAMES coordinates the despatch of fire-fighting and ambulance units, including the names of all the emergency personnel on board. It uses the Global Positioning System to guide these emergency vehicles through the routes that will let them arrive in the shortest time. At the site, paramedics can attend to the injured and quickly transmit information back to the emergency centre or hospital using touch pens and tablets with templates of the human body.

An emergency closer to home was the Severe Acute Respiratory Syndrome (SARS) crisis of 2003. Once the illness was identified and its symptoms known, ST Electronics, working with DSTA, took all the known technology at hand and put together the Infrared Fever Screening System (IFss) in just one week. The thermal scanner was a military solution while the software was originally used to monitor MRT rail heat. The technology resided in different parts of the company, but the speed at which they could be pulled together is testament to the tight integration of ST Electronics' subsidiaries and departments. The cameras were pooled from the SAF and DSTA. The IFss was installed at the entry points to Singapore.

In this crisis, engineers worked round the clock to create systems not only to detect fevers but also to manage contact tracing and tracking. This integrated solution probably saved lives. It was so successful that *TIME Magazine* listed it as one of the "coolest" inventions of 2003.

Whether upgrading a system or integrating a group of disparate systems, ST Engineering's men and women work at the cutting edge of today's technology. But what the future holds is more challenging and ST Engineering will be there to make it happen.


Light The Way

Innovation has been a key part of ST Engineering's ethos from the very beginning. It started with Sir Laurence Hartnett's use of brass rods in the manufacturing of 5.56mm bullets, an unconventional method that turned out better bullets.

As ST Engineering's pioneer companies ventured into making products under licence, for example, the M16 rifle, or through technology transfer in the case of the missile gunboats, the pioneers learnt from the experience. The process of upgrading or modifying aircraft, ships and land vehicles also created the foundational capabilities vital to turning ideas into practical systems. Eventually, they would be able to design and manufacture their own munitions, weapons and fighting platforms.

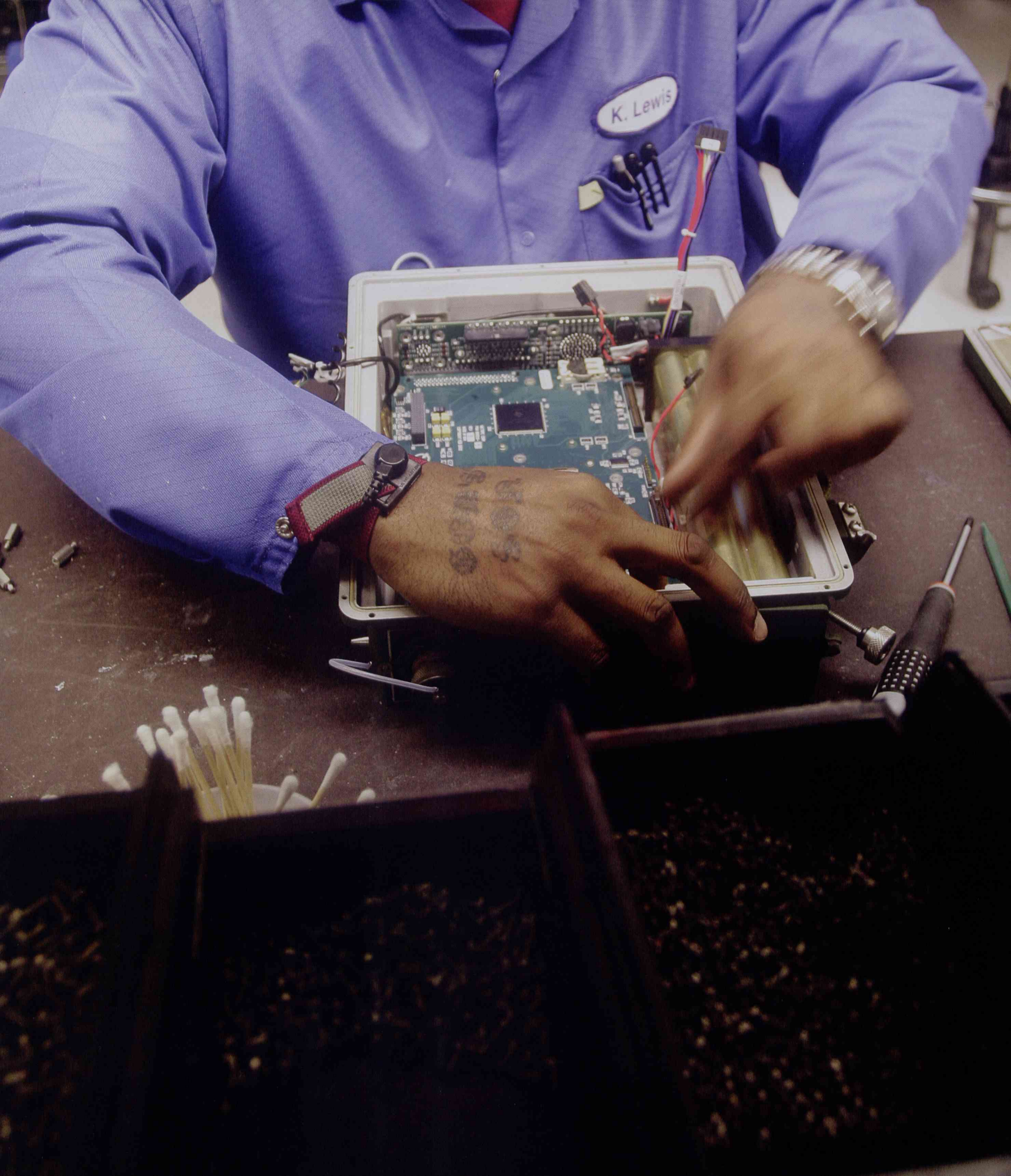
While early efforts like the SAR80 assault rifle did not provide significant technological advances and advantages over its contemporaries, they were important points in the learning curve of ST Engineering's people. The experience from such early projects would prepare the way for breakthroughs like the Ultimax 100 light machine gun and the SAR21 assault rifle.

CHAPTER FOUR

(L to R)
1. A shipyard worker shaping a steel part.
2. An international and innovative workforce is ST Engineering's biggest asset.

For the spirit of innovation to be written into the DNA of an organisation, a company needs to have processes that encourage it, and people with enough talent, passion and will to try to improve and create new things. Using the tough benchmarks of the Singapore Quality Award is one of the ways ST Engineering stays at the top of its game.

CEO Tan Pheng Hock said, "When we went into the SQA application process, it was not intended for the purpose of winning the award. It was to ensure that we encapsulate and formalise our practices, put our DNA framework into perspective, use the SQA process as a health check so that we can identify our weaknesses and improve on them. At the same time, it serves as a check as to how we benchmark against our competitors, whether we have the standard to match or even exceed our competitors. It was to push us beyond what we were at that time."


K. Lewis

(L to R)
1. Before a robot can be programmed to do a job, the judgement of a human being is crucial.
2. Training and development for ST Engineering employees is an on-going process, often involving an international group.

(Opposite)
Prototyping requires the skills of top-class technical people.

Creative Culture

"Successful global enterprises are innovative enterprises," said Mr Tan. "However, innovative enterprises may not always be successful ones."

For innovation to lead to success, an organisation needs three things: a culture of innovation, a way to use innovation and keep it going, and a commitment to research that must go on in good times or bad.

"Innovation is a mindset," said Mr Tan. "The leadership must chart and clearly communicate an innovation mission and strategy for its people. A workforce accustomed to thinking out-of-the-box will yield a rich pool of ideas containing gems of creation. Experimentation and tolerance of failure are encouraged in innovative organisations. Only by trying the impossible or improbable can the boundaries of knowledge be pushed further and further."

To give an innovative mindset form and focus, an organisation also needs a framework for capturing and sustaining innovation.

"Enterprises need to take a disciplined and integrated approach to encouraging, documenting and rewarding innovation. The framework should also provide steps to transform a conceptual idea into a revenue-generating solution," said Mr Tan.

For the men and women of ST Engineering, this framework takes many forms: suggestion scheme, principles of Kaizen, Economic Value-Added projects, innovation competitions and quality circles. To complement these fundamental parts of the framework, individual companies have their own formal schemes to encourage, fund and reward idea generation, exploration and development of ideas into marketable offerings.

ST Electronics, for example, has schemes such as the Exploration/Incubator Fund (EIF), which is supported by $2 million in funding. Meant for idea exploration outside mainstream projects, the fund is used to support design and development as well as the building of prototypes, feasibility studies and technology demonstrations.

ST Engineering also runs a Business Innovation Competition and presents special awards to individuals or teams that are awarded patents. From suggestion schemes to patent awards, there is room for all ideas – and that means room for every person in

(Above)
Introduced in the 1980s, the Ultimax 100 is still the world's lightest machine gun when equipped with a 100-round drum magazine.

the Group to contribute. Generating ideas, however, is not enough. The people of ST Engineering must also be open to new ideas and be ready to evaluate them, and if possible, leverage on them.

People Powered

"As we move towards a knowledge-based economy, the value of human capital will grow as it represents the combined knowledge, skills and capabilities of an organisation collected through the years," said Mr Tan.

"Physicist and Nobel Laureate Albert Einstein summed it up nicely: 'Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world.' It is this spirit of discovery that we strive to develop in our people.

"At ST Engineering, our emphasis is on developing our people into creative, thinking and innovative individuals and team players who help us meet our business objectives. However, for a group as diverse as ours, accomplishing this is not an easy task. Each business unit operates under different conditions and industry expectations. As we grow globally, we will have to deal with the issues that come from managing an international workforce. We believe that effective communications, internal and external, will help us make that path a smoother one.

"The real latent power in human capital can only be realised when employees are informed, enabled and motivated. They must be treated like valued partners working in an independent ecosystem. Only then can we stimulate the generation of ideas that will have a positive impact across our operations."

The First Shot

The creative output of ST Engineering today in all four strategic business areas is massive. But the long lists of locally designed and manufactured products, systems and services, if arranged chronologically, would have, near the start, an almost forgotten product. While Marine built naval craft using technology transfer as a start, Electronics integrated off-the-shelf systems and Aerospace serviced aircraft, a group of engineers from CIS were working on the first locally made rifle, the SAR80.

Using the experience in building the Colt M16 under licence, this assault rifle incorporated tried and

(L to R)
1. The Ultimax 100 was marketed overseas with a team of women to demonstrate the lightweight, ease-of-use and accuracy of the machine gun.
2. The SAR88 - an improved version of the SAR80.

tested rifle technology of that era in a practical package that cost just two-thirds of an M16.

"The SAR80 came about because CIS was tied down to the licensing agreement with Colt. They could not sell the M16," said LG (Ret) Winston Choo. "They felt they should do something of their own that they could sell."

It was not a weapon designed for the SAF. General Choo said CIS wanted the SAF to adopt it, but the SAF felt that the new rifle gave it no added advantage.

"When you want to sell a weapon, you've got to be able to say your own army uses it," he said. "So the guards at the Istana used it. It was a product display. And in those days, when the SAF went for shooting competitions with foreign forces, we used the SAR80 so that other countries could see it. The SAF was really looking for a quantum leap in design. When you look at equipping an army with assault rifles, it's in the hundreds of thousands. And it was only slightly better than an M16."

The Ultimax 100

The first weapon created by CIS that really caught the attention of armies round the world came soon after the good but unremarkable SAR80. Over 20 years later, it is still the world's lightest machine gun, used by many foreign forces and especially favoured by special units. For the SAF, it provided that "quantum leap" from the weapon it was using in the role of Section Assault Weapon (SAW). The Ultimax 100 is still used by the SAF today.

"Until the Ultimax 100, we had no SAW," said General Choo. "We were using a heavy-barrelled SLR which was heavy and inaccurate. There was nothing to complement the AR15, except perhaps a General Purpose Machine Gun (GPMG) which was rather heavy for that level. The SAF was looking for various models and CIS asked if they could make the SAF one."

Two American designers were brought in – James Sullivan and Robert Waterfield – to help in the creation of the new SAW. The result was an excellent lightweight weapon that fired 5.56mm rounds on automatic from either a 30-round magazine or 100-round drum, without the inconvenience of a belt-feed.

To market the weapon around the world, CIS got slim, beautiful women in jumpsuits to demonstrate the accuracy and lightness of the machine gun.

(Above)
S.R. Nathan, President of Singapore, and Chief Defence Force Lieutenant-General Lim Chuan Poh viewing the SAR21 showcased at Army Open House 2001.

A Rifle for the 21st Century

"The SAR21, unlike the SAR80, provided that quantum leap from the M16," said General Choo. The bullpup rifle, with an integrated sighting scope and laser acquisition device (LAD), was a radical departure from conventional rifle design.

Designed right from the start with the Singapore soldier in mind, the sighting scope does not have to be adjusted for an individual user and provides a magnified view of the target – a good thing as many Singaporean soldiers wear spectacles. Shorter than an M16, the SAR21 is a relatively easier rifle to handle than the M16. And with its LAD, a soldier can aim and shoot accurately without even raising the rifle to his shoulder. Accuracy is further enhanced by the SAR21's extremely low recoil.

Lieutenant-General (Retired) Ng Jui Ping, also a former Chief Defence Force, said that the new rifle was created not because there were no other rifles to buy, but because the needs of the SAF soldier were different.

"The Asian frame of the SAF soldier does not have the occidental skeletal structure many advanced countries' rifles are designed for. The terrain in our region is also quite different from the typical terrain of Western countries that produce these advanced rifles. A comprehensive solution for the individual infantryman's innate firepower should look not only at what he's holding but the entire logistics and supply system that must be deployed which delivers the ammunition and spare parts to him so that what he has in his hands continues to be useful hour after hour, day after day."

The changing role of the infantryman also had a part to play in the creation of the SAR21.

"Traditionally, the infantryman was involved in the last part of the assault, storming positions, occupying ground and applying the last part of the *coup de grâce* at close range. Now, you see the infantryman directing aircraft at targets. As an integrated part of the force, he has grown in importance, and how he and his rifle fit into this also has become part of the requirement."

The modern infantryman's primary weapon then must be part of an integrated array of weapons and equipment and yet not hamper him with weight and

(L to R)

1. The SAR21 has been integrated with various state-of-the-art devices.
2. An overseas customer testing the SAR21.
3. Built on a compact bullpup design, the SAR21 is fitted with a sighting device that allows the soldier to shoot around corners.

volume. The development of the SAR21 was clearly no simple task.

"In all developments, there will be problems," General Choo said. "The army wanted an all-singing, all-dancing rifle and had a stringent set of requirements. So it was a case of narrowing down the possibilities from what was desired, rationalising within cost and practicality. It may not meet some wishes.

"When I was Chief Defence Force, we were already working on it. And later on, when I was Chairman of CIS, we were still developing it. Finally, as Ambassador to Australia, I got to shoot it at an SAF Open House – a weapon I had looked forward to for so many years!

"Before I shot, a group of schoolchildren were shooting falling plates from 100m. I was standing behind a girl who was about 13 or 14, bespectacled and not very big. Her first round went astray – she was jerking the trigger. I told her to squeeze, not pull. Her next nine rounds hit the target. It was a tremendous vindication of the weapon and a tremendous experience for me. I think we have, in the SAR21, an excellent assault rifle for the SAF."

More Firepower

However, even before the SAR80, Dr Goh Keng Swee already had plans for developing a local capability to design and build bigger guns. ODE, set up in 1973, started with the GPMG. Although firing a 7.62mm round, a GPMG's high rate of fire required precision engineering that, up to that point, the local defence industry had no experience with. The minimal facilities they had compounded the problem.

Eventually, ODE's fresh young engineers managed to put together a GPMG. Unfortunately, they could not get it to fire consistently, with the gun stopping only after a burst or two. Returning to their drawing boards often, the men persevered and finally managed to get it to work consistently – until they had to change parts, a necessity in combat conditions. Eventually, they sorted out the problem and the GPMG has since been a part of the SAF's small arms arsenal.

The GPMG, however, was only a stepping stone towards Dr Goh's larger aim of building a capability to produce artillery pieces – howitzers, no less. This project began in 1983, when ODE won the contract to build the FH88. In the intervening years, ODE's

LEST WE FORGET

"At ST Engineering, we believe that accidents are not inevitable. They are preventable and we do our very best to ensure the safety of our colleagues, our customers and the people they serve.

"In our 40 years of operations, we have achieved an enviable safety record. But it is not flawless. We have made mistakes. Some mistakes can be measured in material cost. Injury and death cannot.

"We make sure that after a mistake or a near miss, the incident is investigated so that we know what went wrong, learn from it, change from it and ultimately never forget the lessons.

"The people of ST Engineering are constantly reminded that safety is top priority in all our facilities, processes and products. We search constantly for a better and safer way to do things to ensure the safety of all our people and customers.

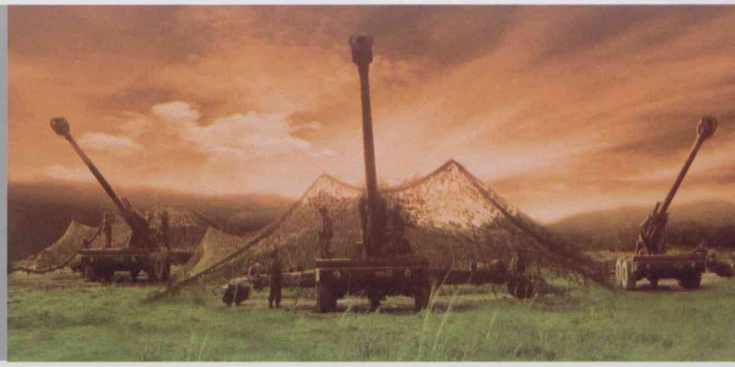
"We will not forget our mistakes or near misses. We make sure we learn from them."

– Tan Pheng Hock

(L to R)

1. The SAF fielding the world's first 52 calibre 155mm field howitzer, FH2000, during an overseas exercise.

2. The FH2000 is designed to fire NATO Type-classified 155mm projectiles.



engineers had designed and built mortars and even modified howitzers the SAF had acquired. Refurbishing the guns also gave them some idea of what the locally-designed and built gun should not be like. They were confident that they could do it.

It was a project that gave the engineers many headaches and sleepless nights. Professor Lui Pao Chuen, Chief Defence Scientist, admits that he was not for the idea then.

"I was not supportive of it. Bofors, for example, had already designed and built an excellent 155mm gun, so why reinvent the wheel? But we did need a gun to be more efficient to meet our needs. One that needed fewer crew, was operationally superior to the Bofors gun, and with a developmental and production cost still cheaper than buying a Bofors. But Lee Hsien Loong, then Assistant Chief of General Staff (Operations), and Teo Ming Kian persuaded MINDEF. So eventually we developed the capability to design and produce guns from GPMG to 155mm howitzers."

The project took four years, with many failures before the gun worked reliably. Professor Lui recalls the gun failing every three rounds. The engineers got together and eventually fixed all the defects, creating a very reliable weapon. Delivered in 1987, the FH88 was followed later by the FH2000, the first 52 calibre gun in the world to be fielded. It has a longer range, deploys quicker, thanks to automation, and needs fewer crew than equivalent systems from other manufacturers.

Move Those Guns

A howitzer, barring combat damage, can last a long time. But the SAF's needs have also changed in the two decades since the FH88 entered service. Today's doctrine calls for howitzers that are air-transportable and capable of moving over difficult terrain with an armoured force.

The lightweight Pegasus howitzer can be transported slung under a Chinook helicopter. Weight was not the only consideration – how the gun would behave under the helicopter as it flew was very critical to ensure the safe transport of the gun, not to mention the safety of the helicopter crew.

The Primus is a howitzer that sits on top of a tracked chassis, enabling it to move in rugged terrain. It is the world's lightest armoured self-propelled

Weighing only 5.4 tons, the Pegasus is air-transportable by a C-130 and CH-47 Chinook helicopter.

(L to R)

1. The lightweight Pegasus enables it to be towed by medium-sized vehicles.
2. Its ammunition loading system enables the Pegasus to deliver a high rate of fire.
3. The 4-man crew Primus has a range of cutting-edge automation technology built into it.

155mm howitzer, complete with digital fire control and programmable munitions magazine on board.

These new guns provided a new generation of engineers with challenges no less difficult than the FH88. The Pegasus was particularly challenging, as part of its solution to meet the weight budget came from the use of titanium, which Wu Tzu Chien, President of Special Projects, describes as an adventure all its own.

Fann Chee Meng, now a Principal Engineer with Kinetics Design and Development, ST Kinetics, said, "The most challenging projects that I had worked on were the Primus and Pegasus. Challenging in the sense that Primus was the first project that I was involved in and my lack of experience certainly affected my quality of work. In addition, there were many designs and production challenges due to weight and space constraints. These challenges were finally overcome by strong teamwork and encouragement."

Like his predecessors in the FH88 project, Mr Fann and a core of committed colleagues rode out the tough times.

"Pegasus was another interesting project," he said. "The special operational requirements of the gun – that it must be able to 'fly', move on its own power, be towed at high speed and ready to fire and scoot within a few minutes, all with minimum manning – made it very challenging. Engineers involved in the project were on a steep learning curve. But like the Primus, it was teamwork that helped to see us through to success."

And fly it does – not only with its own 5.4 ton weight beneath the helicopter, enabling the Pegasus to be deployed expeditiously to where it is needed. Mr Wu notes proudly that the Pegasus has quite a number of patented systems and components. It is a world first and one of its kind in the world.

Go Armour!

The Bionix Infantry Fighting Vehicle (IFV) is Singapore's first locally designed and built armoured fighting vehicle. Born out of the unique needs of the SAF, it was the first indigenous IFV developed by the local defence industry in partnership with HQ Armour and DSTA.

(L to R)
1. The Bronco undergoing trials overseas.
2. The new and improved Spider offers a collapsible roll cage frame that allows the vehicle to be air transportable in a C-130 aircraft.

To mitigate technical risks, various exploratory programmes on subsystems development were initiated, which confirmed that the local defence industry had the capability to design and integrate the first IFV locally.

Completed in just under eight years, the Bionix has more protection, firepower and mobility than other vehicles in its weight class. Very few armoured vehicles allow the crew to fight from within the vehicle using externally mounted weapons.

"The Bionix was a watershed programme for us," said Mr Wu. "We designed everything from the ground up. The full package was integrated by us.

"A principal consideration was size – the SAF wanted us to pack it all into a small box, into a certain volume and weight class, but with the same amount of equipment found on bigger class vehicles.

"We integrated an engine from Detroit Diesel, which is in the same class as the engine of the M113 but of significantly higher power. This was done for ease of logistics support, especially out in the field.

"There were many creative ideas involved. The power pack consists of matching cooling, air intakes and exhaust systems and an electronically controlled fully automatic transmission. We have the option of a cooling system that would have to work in an ambient temperature range as high as 52 degrees Celsius to minus 20. After all, if we want to market the vehicle globally, we might have to go somewhere much colder. Then there is the challenge of making it comfortable for the men, providing space for weapons and munitions and the all-important weapon and crew protection systems."

The key features of the Bionix IFV are the superior survivability and mobility solutions integrated into the platform with much consideration for crew comfort and human ergonomics despite its small size.

Although the Bionix is just over a decade old, there is a new and improved version which is integrated with the Battlefield Management System to enable it to network with other fighting formations on the battlefield as part of the Third Generation transformation of the SAF. Its many variants perform a wide range of combat roles and it can be used as a recovery vehicle, a bridge layer and a platform for combat engineering roles.

Backing the Bionix

Interestingly, Bionix is significant to ST Engineering in another way – it is the vehicle that helped the group enter the tough US market.

Boon Swan Foo, former Deputy Chairman and CEO of ST Engineering, described the marketing campaign for the Bionix as "the single most important expedition that changed the colour, character and confidence of ST Engineering".

"It is a true reflection of courage and takes plenty of initiative and proactiveness to reach into the depth of the customer's territory and be recognised as a credible contender," he said. The Bionix made it to the final list of candidates for the US Army's Interim Armored Vehicle.

ST Kinetics' Military Line-up

ST Kinetics has through the years built up an impressive portfolio of designed and made-in-Singapore products:

1. Ultimax 100 – Introduced in the mid-1980s, this is still the world's best and lightest machine gun with minimum recoil.

2. 40AGL – Introduced in 1993 and upgraded recently, it is the world's second most popular 40mm Automatic Grenade Launcher and has been sold to more than 20 countries.

3. FH2000 – Commissioned in 1995, this was the world's first 52 calibre 155mm howitzer fielded. Its predecessor, the FH88, was Singapore's first indigenously designed and built 155mm howitzer.

4. Bionix – Rolled out in 2000, the Bionix Infantry Fighting Vehicle was a finalist in the US interim Armored Vehicle programme. Today, the Bionix comes in a few variants and is fully network-enabled.

5. SAR21 – Probably the finest assault rifle in the world with a patented safety system to provide the maximum protection possible, the SAR21 was introduced in 2001.

6. Self-destruct fuze – Installed in ST Kinetics' 40mm munition, this patented fuze introduced in 1999 is still the world's only mechanical self-destruct fuze.

7. Bronco – Brought out in 2002, this versatile and agile articulated tracked carrier has a high payload of 5 tons and over 15 variants.

8. Terrex – Rolled out in 2003, the Terrex is an 8 x 8 wheeled armoured carrier that can be transported by a C-130 aircraft without special preparations.

9. 40LWAGL – Not satisfied with just having the second most popular AGL in the world, the 40mm lightweight AGL was introduced in 2004 and is the world's lightest AGL capable of firing ST Kinetics' air bursting munitions.

10. SRAMS – A 120mm mortar tube is nothing unusual, unless it has the lowest recoil force in its class and boasts a 10 rounds per minute rate of fire.

11. Primus – Mounted on a tracked chassis, this 39 calibre 155mm self-propelled howitzer was commissioned in 2004 and comes with a patented ammunition handling system.

12. Pegasus – The lightweight self-propelled 39 calibre 155mm howitzer was introduced in 2005 and can also be transported by helicopter.

Since 1999, ST Kinetics has filed over 80 patents for its innovative products and more than 40 have been granted.

(Above)
The Terrex is equipped with an independent suspension system, which greatly improves ground mobility and ride comfort over the roughest terrain.

(Below)
The SRAMS weighs only 1,200 kg and can be fired from onboard a wide range of light vehicles.

Infantry Artillery – CIS 40AGL

Selling to more than 20 countries, ST Kinetics is today the world's number two supplier for the 40mm Automatic Grenade Launcher (AGL) and the world's number one in 40mm ammunition. It all started with the belief that armies of the world would require a more effective area weapon to complement existing direct weapons. Without any firm local or clear international requirement and little in-house knowledge of the 40mm high velocity ammunition, ODE went ahead to launch the project with internal funding. At that point in time, there were only a few armies with a small number of 40AGLs in service. ODE engineers focused on simplicity in design, reliability in performance and ease in maintenance. The end product speaks for itself. The Gulf War popularised the application of 40AGLs and many countries, including Singapore, have since made the CIS 40AGL their Area Support Weapon of choice. The development of the CIS 40AGL is a key milestone for ODE's small arms business as it helped to establish ODE and the then CAI as a total 40mm system supplier of ammunition, weapons and weapon mountings.

(Left)
ST Kinetics' CIS 40AGL is the world's second most popular 40mm AGL.

Not All Military

ST Kinetics' innovative products, systems and services are not all military, though. It also produces equipment that the public might not quite notice in the background, but which nevertheless play an important role in our lives. Excavators, dump trucks, emergency vehicles and distribution vehicles for food and beverages are part of ST Kinetics' range of specialty vehicles and equipment.

ST Kinetics' line-up of specialty vehicles in the US range, from road construction and maintenance equipment to distribution products and urban services vehicles.

In China, ST Kinetics designs and produces specialised heavy vehicles such as off-road dump trucks, bulk cement tankers, concrete mixers, terminal prime movers and excavators.

The permanent launchway was completed in June 2006. With this new investment, ST Marine can now launch vessels itself. The launchway is equipped with a 150-tonne portal crane, which allows pre-erection of blocks to bigger blocks and shortens the lead time of vessels at the permanent launchway.

See the World

Phua Siang Ling, Senior Manager (Hull), ST Marine agrees that he has had a very satisfying career.

"The company gave me the Overseas Training Award for me to further my studies in England. When I got back, I was given the opportunity to work in both shiprepairs and newbuilding operations, as well as the commercial part. This has allowed me to have a complete picture of what we do and how we operate. The opportunity to learn overseas was always there. I was given the chance to travel to Japan, Europe and China, etc, to see how overseas yards operate, and to bring back good practices and processes that they used. Only by learning and benchmarking with other yards can we further improve ourselves to the next level. In fact, every overseas trip is a new learning curve for me, as there are some processes and good practices you won't believe till you've set eyes on them."

(L to R)
1. The 80m platform supply vessel captured the high-value specialised vessel market.
2. The launch of a petroleum barge with a 185,000-barrel capacity.

(Opposite)
Stealth frigate under construction.

The Terrex is a quite different vehicle, built with wheels instead of tracks, enabling it to travel faster on roads and making it more suitable for urban warfare. The narrower width of the Bionix and Terrex also means these two armoured vehicles can probably move through small streets and over narrow bridges much more easily than typically broader armoured vehicles.

Another two well-known vehicles in ST Kinetics' portfolio are the Light Strike Vehicle (LSV) and the all terrain articulated tracked carrier, Bronco.

The LSV has remained one of the favourite vehicles with the SAF's soldiers because of its very high mobility over all kinds of terrain. With its articulated steering and ability to swim, the Bronco was able to perform some rescue missions in the wake of the devastating Asian Tsunami of 2004.

The Bronco story started with a "$5 million bet" to produce an all terrain tracked vehicle with superior mobility and payload-carrying capacity. ST Kinetics had its concerns at the onset as it was up against an established international market leader.

"How can we compete against the market leader who had built over 10,000 vehicles? So we decided to introduce an innovative feature to change the rules! We proposed a vehicle with much higher carrying capacity," said Fong Saik Hay, Senior Vice President of Engineering at ST Automotive then.

The higher capacity Bronco meant that fewer vehicles and operators were needed to transport the payload in the battlefield, thus making it more cost-effective and significantly reducing the logistics tail. A $5 million prototype was built and its superb performance during trials helped ST Kinetics secure an SAF contract in 1999.

Uncharted Waters

In the shipbuilding industry, every new ship has the potential for innovation, and every upgrade or conversion is an opportunity to put in the latest systems using the latest techniques. Making something new – or better – whether through improved components or processes is innovation.

Ng Chun Wee, Assistant Principal Engineer, said, "I've been with ST Marine for almost three years and the company has offered me numerous opportunities to be involved in the design and engineering of all


69

A commercial newbuild nears completion.

(L to R)

1. An innovative design by ST Marine – a fast "Bangkok" class Super 1018 TEU feeder container vessel.
2. The 1030 TEU feeder container vessel is designed to achieve a high service speed.
3. The launch of the *Island Home* at VT Halter Marine.

(Opposite)
Technology transfer – ST Marine designed, built and packaged "shipbuilding kits" for six 45m inshore patrol vessels for the Indian Coast Guard.

kinds of shipboard mechanical systems: from fuel oil systems, propulsion systems, to sanitary waste discharge systems... the list goes on. The field is so wide and diverse and there is still so much more to learn from my seniors and superiors in ST Marine, even after three years here.

"Life can be tough and challenging when we are nearing the delivery of a shipbuilding project, and problems in design and engineering start surfacing, but nothing beats the satisfaction of seeing 'our' ship finally delivered to satisfied customers and knowing that all the hard work by the project team has finally paid off."

Although there are ship "types" or "classes", no two ships in the same category need actually be the same. Given the long service life of ships, it is also possible to upgrade or modify a vessel to become something very different from what it began life as. Indeed, many owners choose the path of conversion or modification as a lot of time is saved and an almost new vessel can take to the water sooner. While getting into the water sooner may mean generating returns sooner for an owner, a conversion or upgrade is not necessarily cheaper. Engineers have to find ways to install the new systems and get the new systems working with each other.

While it is obvious that the way a ship is built is open to innovation, it is less obvious that even the way facilities and equipment are arranged in a yard can be innovative. ST Marine's Singapore yards, for example, are comparatively small, but the use of space is optimised for work flow, thanks to the feedback of workers and customers. When the French designers of the RSN's frigates first visited Benoi Yard, they were sceptical that vessels of that size and complexity could actually be built there. But since then, these frigates have been built at Benoi – while work on other vessels continued without problems. Innovation comes from the ability to say "yes" to a customer – and "no" to perceived limitations. ST Marine is living proof of that.

Working only with Benoi Yard, Tuas Yard and the VT Halter Marine yards in the United States, ST Marine is looking for places where it can build bigger vessels.

"Some good possibilities are China, India and Vietnam," said See Leong Teck, President of ST Marine. "But they need to be big yards. This is because we're looking towards repairing and building bigger vessels.


COASTGUARD

(L to R)
1. The 55m Patrol Vessel is fitted with waterjet systems instead of conventional propellers.
2. The 49m Landing and Supply Craft for the Kuwaiti Coast Guard.

Our own yards are not big enough. We're not looking for a global network of yards for its own sake. There's no point in getting more yards overseas unless they allow us to work on larger vessels.

"Location is also another factor to consider. For shiprepair, this is important, whereas in shipbuilding, it is less so. Building standard design ships and repair jobs tend to move to countries with lower costs," said Mr See.

The Shape of Ships to Come

With the world's energy demands, there are many rigs scattered around the oil and gas producing areas of the Earth. Standing alone against the mighty seas, rigs and their crews need to be supported by platform supply vessels. These large vessels with their long flat decks are perfect workhorses, moving supplies to rigs and other vessels.

But when there is a need to move large amounts of goods from port to port, ST Marine's feeder container vessels can do the job. When the cargo happens to be carried by trailers and vehicles, customers can order special vessels, like the RoRo ships. Moving many people quickly over water for relatively short distances needs fast, comfortable ferries, and this is something that ST Marine excels at too.

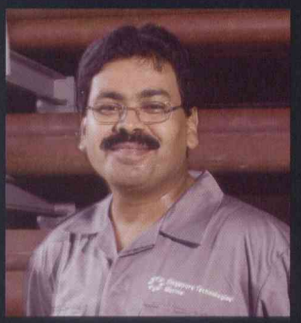
Naval vessels are still a mainstay of ST Marine. From small coastal patrol craft and fast craft for transporting people and equipment, to missile gunboats, corvettes, patrol vessels, landing ship tanks and frigates, ST Marine has a large repertoire of naval vessel types it can build. ST Marine can also build hovercraft and ships with stealth technology.

Said Mr See: "Compared to other small yards, we have a strong in-house design capability which gives us an advantage. We will still build a ship designed by others if that is what a customer wants, but more and more, we have been using our own designs. Our ability to customise a ship design to suit the specific needs of a customer cost-effectively for small fleet size, as we do not have large shipbuilding capacity, makes us different from many other yards."

The Landing Ship Tank

Apart from small patrol boats, the RSN's Landing Ship Tank (LST) is the first naval vessel designed

(Opposite)
The 141m Landing Ship Tank is designed and built locally by ST Marine. The sophisticated vessel is versatile and has low manning requirements. It sailed around the world in 2000 and has assisted in disaster relief in Aceh and Indonesia.



Experience is Precious

Mr Sivakumar, Department Head (Mechanical & Piping), ST Marine, joined the company as a pipe fitter when he was only 19. He started by writing the field reports for all the work in piping.

He moved into ship system commissioning, becoming a supervisor. He faced challenges like converting ships without the original drawings.

"I was new and I was still learning by doing," he said. "It gave me the confidence to do other projects. But I also pursued part-time studies at the Singapore Institute of Technology.

One of the ultimate projects he worked on was the Landing Ship Tank for the RSN.

"I still remember every single pipe and valve," he said, with a mixture of pride and affection. "Other than engines, generators, deck machinery and navigation systems, every other system was commissioned by the piping department. I was involved in most of the commissioning of the piping system."

Clearly, Mr Sivakumar's experience contributed to the success of the LST's piping system. But this level of experience may be difficult to come by in the future.

"In the past, people stayed 20, 30 years in their jobs," he said. "Especially in shipping, many of our men had lower educational qualifications. Now, with more education, people are more mobile.

"In our industry, experience gives us a 90 per cent chance of success. It plays a very large part. We're training young technicians and engineers. But some skills, like pipe fitting, are no longer taught at the technical institutes in Singapore and around the world. So we have to train these men ourselves."

It's a tough industry, and the men in it have to be tough too. And they are becoming increasingly more difficult to find.

(L to R)
1, 2, 3. ST Aerospace designed and developed the FanTail, a compact and lightweight mini Vertical Take Off and Landing UAV, and the Skyblade, a family of fixed UAVs. UAVs come in modularly configurable systems with an in-house developed miniaturised flight computer.

and built entirely by ST Marine without technology transfer agreements. It is definitely a fine example of an in-house design created to meet specific customer needs.

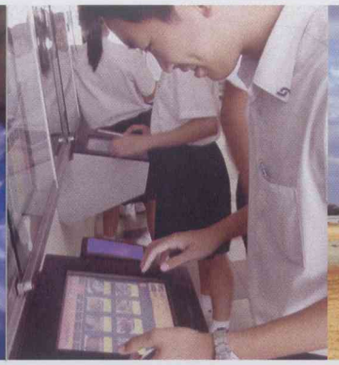
"The new LST for the RSN was a replacement for the old refurbished County-class LST," said Lieutenant-General (Retired) Ng Jui Ping. "When we conceptualised the next generation LST, I didn't think we'd simply build a newer version. Together with the RSN, we conceived a ship that could perform the roles that are required of the LST much better, and with less men to operate. So on the surface, what you see is a large ship – but it is a reflection of the maturity of the defence forces and the industry to work together to define and produce this new generation ship.

The Sky's No Limit

ST Aerospace's clear strength is in aerospace maintenance, repair and overhaul (MRO). What makes it the world's top-ranking MRO company is a culmination of various factors but perhaps there is none more important than its emphasis on safety. Efficiency and excellence also play significant parts in ST Aerospace's success. But the high level of productivity, which translates into less down time for aircraft and more profits for operators, means that work processes have to be continually improving. It is not a matter of working faster with familiarity, but working smarter to increase efficiency. Innovation in work processes is part of life for any of ST Engineering's employees.

The economics of aviation do not make it feasible for ST Aerospace to design and develop its own commercial or military aircraft for sale. But because of its outstanding capabilities in MRO, ST Aerospace has what it takes to design and build major components.

The EC120 helicopter, for example, is a product of an international tripartite effort by Eurocopter (France), CATIC (China) and ST Aerospace to develop a new 1.5 ton, single-engine, 4 to 5 seat helicopter with a range of 700km. ST Aerospace has a 15 per cent share of the programme and its contribution includes the tailboom, horizontal stabiliser, fenestron, cabin doors, console and windows. These components are developed, prototyped, certified and produced by ST Aerospace and then shipped to Eurocopter for final assembly, flight test and delivery to customers.



(Above, L to R)

1. Calibration services allow customers to use equipment more accurately.
2. i-School smart card reader helps in checking attendance, buying things and booking facilities.
3. Integrated Air Traffic Control Tower System and radio navigation for Albania's Kukes International Airport.

ST Aerospace's expertise in design engineering has grown to the point where it is able, with Boeing's support, to design and develop the conversion kit that turns Boeing 757 airliners into freighters.

The Future of Flight?

ST Aerospace might not build its own airliners, freighters or fighters, but it is growing into a significant player in the area of UAVs – Unmanned Aerial Vehicles. These aircraft are capable of being fitted with an assortment of sensors and can fly ahead of a main force as its eyes and ears. UAVs reduce risk and operational costs significantly. They are also much more easily deployed.

UAVs' long loitering times mean an area can be kept under surveillance constantly and for much longer periods. This makes them useful in search and rescue, border security and disaster relief work. An extremely cost-effective airborne platform, a UAV system costs much, much less than a manned aircraft, and UAV pilots and crews need less training time before they can get into action.

Putting It Together

At ST Electronics, innovation goes much further than just bringing together off-the-shelf components for new tasks. Besides the large-scale integration projects that create intelligent rail transportation systems, intelligent building management systems and integrated systems for combat platforms, ST Electronics develops software and makes sensors and communications equipment.

Software development projects are focused on Information Communications Technologies and real-time mission critical systems such as combat systems or public safety systems. ST Electronics also writes the sophisticated codes for the software of training and simulation systems. Not surprisingly, ST Electronics is also able to provide e-learning solutions for many kinds of customers, from schools to armies. Enterprise and e-Government solutions are also increasingly in demand in both private and public sectors. These include resource management, tax collection, communications networks and managed services for local and overseas governments.

(Above)
Installing the in-vehicle unit for the effective fleet management of ComfortDelGro taxis.

Fiona Loke, an engineer with ST Electronics (Info-Comm Systems), gave an example of a typical software job. "My most interesting project was also my first. My job then was to write a module to read licence plates automatically. I really enjoyed being able to freely explore different algorithms to achieve this goal and felt rewarded whenever the module's performance improved."

Hong Kong's Fire Services Department manages its emergency response systems with a solution provided by ST Electronics, as does the Hong Kong Marine Police.

Kevin Cheng, Deputy Director Homeland Security Division of ST Electronics (Info-Software Systems), said the Hong Kong Marine Police system was one of the more challenging projects since he joined ST Electronics.

"It was the first project that our department had secured overseas and we felt like pioneers. I was involved in the project from the tendering phase at the start of it and we had to overcome many difficulties including culture, language and setting up a company for the first time overseas.

"The most important factors for our success I believe were teamwork and perseverance. Despite making mistakes and often feeling exhausted by the long hours and travel, our efforts to encourage one another and not entertain thoughts of failure saw us through to the end."

The Botswana Government has implemented ST Electronics' solutions for its tax collection, as well as for an Internet-based digital network that aids crime and criminal management to keep its communities safe, and centralised and streamlined its data on mines, minerals and geo-scientific information. More than 1,000 schools in Kazakhstan use multimedia laboratories and e-learning solutions implemented by ST Electronics.

Through the same core competencies that are needed for interactive computer graphics generated for training and simulation development, ST Electronics has taken a step into the realm of digital animation. It has produced TV series and movies with world-renowned players like Nelvana, Promenade Pictures and Weta Workshop. This is an exciting new area of business for the company.

(L to R)
1. A dispatcher puts the system to the test.
2. Administrators synchronise the remote system with taxi drivers.
3. Running the Hong Kong Fire Services Command Centre.

Keep In Touch

Communications and sensor technology helps people keep in touch. ST Electronics uses satellite, broadband, wireless and data communications technology to create systems that keep people, sensors and computer systems connected.

Lionel Guow, Chief Technology Officer of ST Electronics (Info-Comm Systems), remembers a generic fleet management system he worked on in 1993, based on the Global Positioning System. His timing could not have been better. In 1994, with some encouragement from the Land Transport Authority, almost all the major taxi companies wanted to implement a GPS-based taxi dispatch system.

"We were fortunate to be awarded by Comfort Transportation, the contract to implement the system for their fleet of 8,000 taxis. The implementation involved the development of the mobile data terminal and mobile control unit, dispatch back-end software, interfacing to the Mobitex data communication network, interfacing to an Automatic Call Distribution system, developing an Interactive Voice Response System, training the call centre and driver trainers, installing the in-vehicle equipment into the 8,000 taxis and so on."

At the peak of the project, there was "no night or day" for Mr Guow's team. But the satisfaction was great. Before the system was implemented, customers had to wait half an hour for their call to be answered by the operator. Another half an hour would elapse before the operator called back with the booking details. But with the new dispatch system, the whole process takes less than 20 seconds. Today, ComfortDelGro's 15,300 taxis are powered by the ST Electronics fleet management and telematics system.

ST Electronics also handles the infrastructure for e-Government solutions, not just its software. The 24 islands of the Maldives, for example, are connected through a network that enables government agencies to share their information electronically and provides access to common applications and services, as well as allows the public to access government information and services through the Internet.

Information security and mobile systems have become increasingly important for modern

With its track-based design and superior mobility in waterlogged areas, the Bronco conducted search-and-rescue operations during the 2004 tsunami crisis in Thailand.

Homeland Security

With terrorism threatening the safety of civilian populations, defence technologies are increasingly being adapted for homeland security, including perimeter security, to protect our homefront and way of life. Governments, private enterprise and communities can monitor, protect and respond to emergency situations with the appropriate systems.

ST Engineering's capabilities and technologies in aerospace, electronics, land systems and marine provide the basic building blocks for integrated homeland security solutions including Maritime, Aviation and Port Security Solutions, Mobile Track and Trace, Biometric Identification Systems and Threat Containment Vessels.

(Above, Top)
The Police Riot Vehicle was developed for the Singapore Police Force for deployment during the 2006 International Monetary Fund World Bank Summit.

(Above, Bottom)
The Mobile Crash Barrier deployed for security operations.

Learn – And Innovate

"In recent years, I have moved from engineering work into technical consultancy for business development. My current scope has led me to expand my technical knowledge into new areas such as hazardous materials, non-intrusive imaging and information management. More significantly, being involved in business development has sharpened my business acumen and improved my skills in building relationships with both customers and partners. The need to learn continuously and to compete in today's world keeps my job interesting and challenging."

Kevin Cheng

Deputy Director Homeland Security Division,
ST Electronics (Info-Software Systems)

(L to R)

1. The Hackney Emergency Vehicle is widely used in the United States.
2. The Commercial Articulated Vehicle (CAV) is specially designed for disaster relief operations.
3. The Hazmat Support Vehicle developed for SCDF.

battlefields and business. In the area of sensing, ST Electronics develops and maintains electro-optics and microwave sensing systems. It also integrates and produces subsystems for radar systems.

The work of ST Electronics touches many aspects of modern life. But like the other SBAs, it can only do so if innovation itself is a way of life.

A Way of Life

"The development and use of advanced technology must be a way of life," said ST Engineering President and CEO Tan Pheng Hock. "A focus on ongoing research and development should be supported through good and bad times. To take this a step further, emergent or disruptive technologies should be sought to avoid being waylaid by unexpected technology trends.

"Thomas Jefferson once said, 'Every generation needs a new revolution.' The revolution of our time will be centred on ideas, cultures and technologies. An investment in innovation therefore is an investment in our future. Innovation leads to value creation and long-term sustainable growth. It can contribute significantly to an enterprise's market capitalisation, customer trust, as well as its attractiveness as an employer."

We Save Lives

Born of an urgent need to survive in a dangerous era, ST Engineering has developed significant capabilities in defence engineering. But for the Group, these capabilities and their products are only the means to an end. As Mr Tan put it to ST Engineering's people at August 2007's Business Excellence Seminar: "We save lives."

From keeping aircraft flying safely to creating new ships that can rush to a disaster site to writing software to keep fire watch over a city to building rescue vehicles, ST Engineering's people face challenges that need more than just a few good men or women.


New Horizons

The sun does not set on ST Engineering's world. ST Engineering today has over 100 subsidiaries in 35 cities in 20 countries. Customers come from over 70 countries. Going global was necessary for ST Engineering to grow, and grow it did, penetrating new markets around the world through partnerships and acquisitions.

The Group is always looking for partnerships with complementary technologies such as biometrics, robotics and artificial intelligence. The Group's range and depth of product offerings are thus upgraded and enhanced.

In the United States, ST Engineering's US headquarters, VT Systems, is in the frontline of market growth in the United States. Set up in 2001 in Virginia, near Washington DC, VT Systems delivers ST Engineering's brand of engineering excellence to the Americas in the core business areas of aerospace, electronics, land systems and marine.

Closer to Singapore, the Group already has presence in the aerospace, electronics and land systems sectors in China, with plans to expand into the


CHAPTER FIVE


(L to R)
1. Mechanic at work at STAR Automotive Centre.
2. Data Centre Outsourcing.
3. Maintaining the HMX1100 powerpack.
4. Aircraft seat maintenance in progress.

marine sector too. The Group has an aircraft MRO facility in Shanghai; IT software development centres in Shenzhen and Yichun and an R&D centre in Shanghai; a production plant in Chengdu, STAR Automotive Centres in Guangzhou and Hangzhou; and joint ventures in Beijing and Guiyang to produce specialty vehicles for the construction and mining industries.

The East Asian market is supported by representative offices in Beijing, Hong Kong, Guangzhou, Shanghai, Shenzhen and Chengdu. There are also representative offices further afield in Thailand, Qatar, Botswana, India and the Republic of Kazakhstan.

ST Engineering's potential for growth is as huge as the places it has not yet reached. Where will the Group go from here? What will it need to do to succeed as a global corporation?

Recognition for Excellence

ST Engineering has been recognised for its business management, operational excellence, corporate governance, transparency and technical achievements. Its awards and accolades include:

2007

Singapore Quality Award with Special Commendation from SQA Governing Council

DTP Engineering Award (Team) for Formidable Class Stealth Frigate Integrated Programme Management Team to ST Marine, ST Electronics, DSO, DSTA and the RSN by MINDEF

DTP Engineering Award (Team) for a Classified Project to ST Aerospace, DSTA, DSO and the RSAF by MINDEF

Minister for Defence Award conferred on ST Electronics, the highest accolade of the **2007 Total Defence Awards**

Walter L. Hurd Foundation World Executive Medal conferred on Tan Pheng Hock, President and CEO, by the Asia Pacific Quality Organisation, for his contribution towards Quality advancement

International Management Action Award conferred on Seah Moon Ming, Deputy CEO of ST Engineering and President of ST Electronics, by Chartered Management Institute and SPRING Singapore

2006

Asia Brands Award 2006 – Ten Most Prospective Brands Award won by ST Electronics at the First Asian Brand Award Grand Ceremony organised by The State-Owned Assets Supervision and Administration Commission of the State Department, China Business Times, China Economic Information Bureau, Famous Brands Times and Asia International Famous & Fine Brand Attestation Centre

Innovation in Engineering Award by the Institution of Engineering and Technology (IET), UK

Frost & Sullivan Product Innovation of the Year

DTP R&D Award (Team) for the Pegasus Howitzer to ST Kinetics and DSTA by MINDEF

DTP Engineering Award (Team) for specialised marine craft to ST Marine together with DSTA and DSO by MINDEF

2005

Best of its Class Distinction in the Big Manufacturing Organisation category, International Asia Pacific Quality Award 2005

Associate of the Arts Award 2005 from the National Arts Council, Singapore

International Management Action Award conferred on Tan Pheng Hock, President and CEO, by Chartered Management Institute and SPRING Singapore

2004

Associate of the Arts Award 2004 from the National Arts Council, Singapore

Ranked 6th for **Best Corporate Governance** in Asia's Best Companies 2004 by *FinanceAsia*

2004 Tech Museum Award (Health category) to ST Electronics, together with DSTA and Chartered Electro-Optics

Partner of the Year (Company) Award from SPRING Singapore

Inaugural **International Business Award** from UK Trade and Investment

DTP Engineering Award (Team) for 40mm Air Bursting Munition System to ST Kinetics, DSTA and The Army by MINDEF

President and CEO, Board members and staff at the SQA with Special Commendation 2007 presentation.

Boeing Supplier of the Year Award (SASCO), a premier award to honour supplier's commitment to excellence and customer satisfaction (out of 10,000 suppliers in 70 countries)

2003

1st SIAS Transparency Excellence Award by The Securities Investors Association Singapore (SIAS)

Joint Runner-up, **Best Managed Boards Award** by the Singapore Institute of Directors (SID), the *Business Times*, the Singapore Business Federation, the Economic Development Board and the Singapore Exchange (SGX)

Singapore Innovation Award 2003 – Innovative Organisation of the Year by Singapore Innovation Council

Singapore Innovation Class by Singapore Innovation Award Council

Best CFO awarded to Chief Financial Officer Kuah Boon Wee, in Reuters Institutional Investor Report

ST Aerospace was ranked **World's Largest Third Party MRO Provider** for the first time by McGraw-Hill's *Overhaul & Maintenance* magazine

Patron of the Arts Award 2003 from National Arts Council, Singapore

***Time Magazine* "Coolest Invention of the Year"** for the Infrared Fever Screening System (IFss), jointly developed by ST Electronics and DSTA

DTP Engineering Award (Team) for The Datalink Network Programme to ST Electronics with DSTA, DSO and National Laboratories

2002

SIAS Golden Circle Award (Most Transparent Company) by Securities Investors Association of Singapore

Singapore Quality Award from SQA Governing Council

DTP Engineering Award (Individual) to Dr Richard Kwok, Director of the Engineering Development Centre, ST Kinetics

Outstanding Innovation and Quality Circle Award from SPRING Singapore

Singapore Environmental Reporting Awards 2002

ST Aerospace voted the **Best MRO in the Asia Pacific** by McGraw-Hill's *Aviation Week* magazine

ST Aerospace awarded winner of the **Flight International Industry Award (Maintenance and Modification)**

Gruppo Agusta International Helicopter Fellowship Award to ST Aerospace, in recognition of significant contribution and excellent performance in the Apache programme

DTP Engineering Award (Team) for The Air Command & Control Hub to ST Electronics with DSTA, DSO and RSAF

2001

SIAS Golden Circle Award (Most Transparent Company) by Securities Investors Association of Singapore

Overall Best Managed Company in Singapore by *Asiamoney* magazine

Ranked 4th in **Top 10 Singapore Companies with Strong Corporate Governance**, in poll by *Asset* magazine

Rated one of the **Asia Pacific companies with the highest levels of corporate transparency and disclosure** in Asia Pacific by Standard & Poor's Transparency & Disclosure Standards Survey

DTP Engineering Award (Team) for Landing Ship Tank to ST Marine, together with ST Electronics, DSTA and RSN

DTP Engineering Award (Team) for the SAR21 to ST Kinetics, DSTA and HQ Infantry by MINDEF

DTP (Special Project Team), for enhancement of strategic capability of the customer

2000

SIAS Golden Circle Award (Most Transparent Company) by Securities Investors Association of Singapore

Asia's Top Performing Companies 2000 Award from *FinanceAsia* magazine

Technology Achievement Award 2000 awarded to ST Electronics by National Science and Technology Board, Singapore

International Trade Award 2000/2001 by Trade Development Board, Singapore

ASEAN Engineering Achievement Award 2000 to ST Electronics by ASEAN Federation of Engineering Organisation

Named one of two **Asia's Value Creators** in Singapore by *Asian Wall Street Journal*

First runner-up for **Best Corporate Governance** at the 27th Annual Report Awards

Ranked 2nd in Singapore for Asia's **Best Managed Companies** by *Asiamoney* magazine

DTP (Team) for the Bronco All Terrain Tracked Carrier to ST Kinetics, DSTA and The Army by MINDEF

Tan Pheng Hock, President and CEO, ST Engineering, is proud that the SQA with Special Commendation is a pioneer win.

1999

Voted one of the **Most Transparent Companies** in Singapore by Corporate Transparencies

Special Commendation for Disclosure and 1st runner-up for **Best Corporate Governance** at the 26th Annual Report Awards

Voted one of Asia's **Best Managed Companies** by *Asiamoney* magazine

DTP (E-2C Upgrade Project Team) for ST Aerospace's enhancement of strategic capability of the customer

DTP (F-5 Upgrade Project Team), for ST Aerospace's enhancement of strategic capability of the customer

1997

DTP (Team) for the Bionix Infantry Fighting Vehicle to ST Kinetics, DMO and SAF Armour by MINDEF

Abbreviation:

DTP – Defence Technology Prize

My Second Home

"ST Engineering has helped me grow, and hold dear the people whom I've worked with over the past years. Ultimately, it is the people that matter. After all, for every achievement that we might strive towards, far greater than ourselves is having made an impact on the lives of others, so that they may look back at it one day, and smile.

"Many colleagues have come up to me and recounted their experiences here over many years, and their constant encouragement and thanks have spurred me on to continue doing what I do for the people who make up the organisation. It isn't uncommon for colleagues to drop by my office for an informal chat, sharing their personal working experiences as well as their struggles. And what heartens me the most, is when I hear of how they have overcome their difficulties and triumphed over the challenges they faced.

"In retrospect, I am glad I made the decision to join the company back in 1974. It has become a second home and a place where I've grown, and I cannot imagine myself being anywhere else."

Regina Tan
Senior Executive, Survivability Centre, ST Kinetics

People-focused

"I joined ODE in February 1998 before ST Kinetics was formed as I was keen to work in the field of engineering design. My first impression of the organisation was its dedication to train and equip employees for the growth of the company.

"I believe that the company has not changed its focus on its human resource, which is its most valuable asset.

"The organisation has gone from diversification to convergence of management over the years in the name of business relevance and strategy. Our commercial business has gone from less than 10 per cent in the past to the current 50 per cent. Through these changes, I was also given the privilege of studying in the Master of Defence Technology and Systems Programme and came back to serve in a different role in another centre. Many of my colleagues were transferred to various portfolios and stepped into new ventures.

"ST Engineering has definitely helped me grow both my technical and social skills. I have learnt and am still learning to value the network of working relationships through professionalism and sincerity. The perseverance to keep up-to-date with technologies and to meet the demands of the customer are key to business relevancy and continuity."

Jimmy Chan
Principal Engineer, Kinetics Design and Development, ST Kinetics



(L to R)

1. Preparing to press the 40mm ammunition.
2. Assembling the ammunition rounds.
3. Preparing the ammunition to be marked.
4. ST Kinetics' staff at work at the ammunition production plant.

IT'S PERSONAL

For the Singaporeans in ST Engineering, the Group's role in the defence ecosystem has a more personal and profound meaning.

"As a Singaporean who has gone through National Service and now, in the defence industry, a strategic partner of the SAF, the pressures and responsibility of making sure the products and systems we develop work reliably and consistently, are high," said CEO Tan Pheng Hock.

"That everything must be of the highest quality is not just a marketing statement. All the Singaporeans in ST Engineering know that these products and systems will be used by their family, their friends and others they know. These products and systems must work and work well in times of need. This is a very powerful impetus to the staff to ensure that our products and systems are of the highest standards."

The Defence Ecosystem

Although ST Engineering has changed tremendously, what cannot change is its vital role in Singapore's defence ecosystem.

Wee Siew Kim, who heads the Defence Business group, talked about the constants of ST Engineering's links with MINDEF and the SAF, as well as the new directions the relationship could take.

"One of our enduring strengths is that we are a key strategic partner to the SAF and the growth of ST Engineering has been in tandem with the SAF. If you look at the SAF, you see a mirroring of growth and capabilities. The present third generation armed forces is a reflection of changing demographics – fewer but smarter people using networked automation to push technology to the edge. Our relationship with the SAF has grown closer and we work with them now not just to find solutions, but to envision possibilities.

"A lot depends on our ability to produce prototypes quickly, test ideas and field things quickly and spiral the development. We don't wait 10 years for the 'perfect' solution. We deliver what we can now and develop it over the years. So it is critical to have

Why the Military is Top Priority

"The concern was always and still should be whether ST Engineering might forget that its primary mission is supporting the Ministry of Defence and the Singapore Armed Forces, notwithstanding its status as a listed company," said Peter Ho, Permanent Secretary, Ministry of Foreign Affairs, who was a member of ST Engineering's Board when he was Permanent Secretary, MINDEF.

"The Government has no problem with ST Engineering making money – but would it be so dominant a concern that it would forget what it was established for? This is a dilemma for defence industries, particularly for Singapore, where we have only ST Engineering. In the US, you can throw a stone and hit a number of defence-related companies.

"Building up the business and building up the capability to support the SAF are not mutually exclusive, but if you focus on business and generate business outside of Singapore, the ability to support the SAF might be lowered. What's the right balance?

"ST Engineering's competitive advantage also comes from its relationship with MINDEF. It gives them assured business, some big contracts and new capabilities with some of those.

"Another dilemma comes from the fact that while it is a strategic partnership, MINDEF is also obliged to keep an arm's length from ST Engineering.

ST Engineering has to remain competitive. But there are strategic areas where MINDEF waives competition so as to build up capability and capacity. MINDEF needs the assurance that ST Engineering is prepared to commit resources to build up and sustain capabilities over time.

"At MINDEF, we had to be careful about this. We needed ST Engineering in our long-term planning. It is hard to think of building new capabilities without them, yet we could not give away all our secrets without compromising that arm's-length relationship."

Taking MINDEF out of the equation then would mean losing a competitive advantage, especially in cutting-edge capabilities from MINDEF's Defence Science Organisation. ST Engineering would also lose a key reference customer. And the investor would lose a good defensive stock, underwritten by the defence budget, as Mr Ho puts it.

"The bottom line is that ST Engineering's relationship with MINDEF is vital. That's the real safety net. Even if it loses all commercial business, it still has MINDEF and a good part of the defence budget."

One of the 40AGL components being assembled in ST Kinetics' small arms weapons manufacturing plant.

"There are many models of military and industrial relationship. The way ours has evolved is because of our vulnerabilities as a country. It is a reaction to what we see as threats and what we need to do. Without strategic depth, we need to fight differently."

– Wee Siew Kim

the organisational interaction, the sharing of thinking, bringing the right people together and empowering them to discuss and decide. We are not just vendor and customer – we are part of a defence ecosystem – DSO, DSTA, government research institutes and so on.

"But even though vendors and users are now more closely knit, there are still no shortcuts. We have to recognise that, from the government's perspective, they need to be accountable. That arm's-length relationship is still needed for transparency and accountability."

A Mutual Need

"We need the SAF to need us, to give us their trust and confidence, and to challenge us to deliver increasingly sophisticated solutions, especially where a leap of faith is needed for systems we have never tried before.

"When we built our first FH88 and upgraded our first aircraft, these were things we had never done before. The SAF believed in us, so one generation could build on the next. We hope to keep this trust. On our part, we recognise the need to give top priority to the support of the SAF. There are no two minds about this. We always remind our people about it.

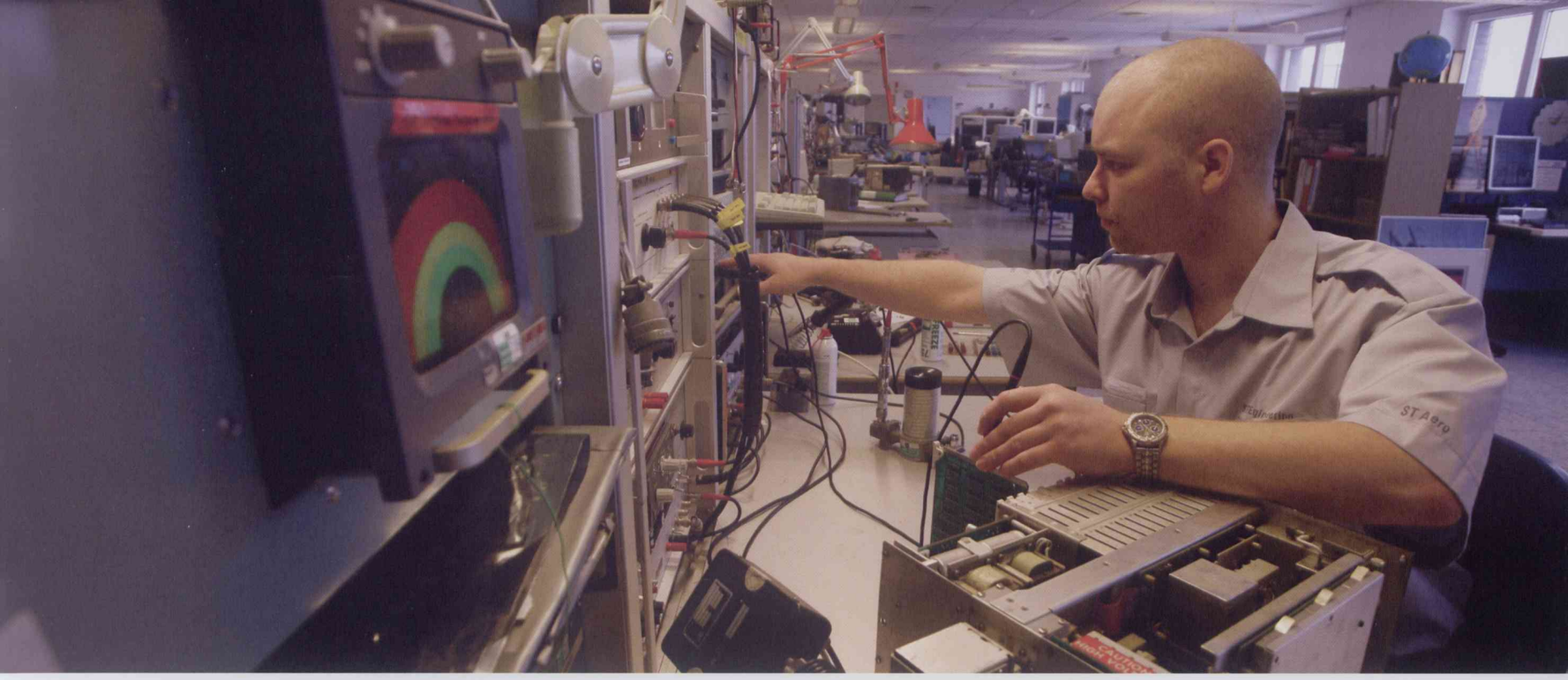
"The Defence Business group has the singular purpose of giving MINDEF 100 per cent attention. We don't leave things to chance. There are lots of forums with the services and us. Nothing is left to fall through the cracks through lack of communication.

"There are many models of military and industrial relationship. The way ours has evolved is because of our vulnerabilities as a country. It is a reaction to what we see as threats and what we need to do. Without strategic depth, we need to fight differently."

Market Discipline is Essential

Teo Ming Kian, Permanent Secretary, Finance, said that market discipline was essential if ST Engineering was to stay competitive from MINDEF's point of view, even if ST Engineering was part of Singapore's defence ecosystem.

"Why does MINDEF have to pay for the products and services it gets from ST Engineering? At the start, it was a question of whether we should have an arsenal that worked just for the military or an organisation



(Above)
Thorough testing keeps aircraft flying safely.

subject to market discipline. We chose the latter. With an arsenal you can never be sure you are going to be efficient and get real value.

"This is not so with competition. A lot of things MINDEF and the SAF buy are in open competition. So if ST Engineering is profit-oriented, it will always be on its toes. And the SAF can still choose other vendors should the need arise.

"Profits also motivate staff. This is how ST Engineering is responding to the increasingly complex needs of the SAF and the global market. My own feeling about it is that while ST Engineering's profits come increasingly from the commercial sector, the Group will never lose sight of its military priority.

"Its underlying capability is dual-use, but it also recognises that depending only on one customer means business can be cyclical. When the SAF buys, it buys in large quantities and then it might not buy for some time. It's a problem of feast and famine.

"This was a problem in the early years of ST Engineering when the SAF was its chief customer. The Group will always be subject to the vagaries of this and will not be able to maintain its capabilities if it does not go elsewhere. If it has more overseas customers, it will be able to sustain its capabilities. So it is helpful to the SAF that ST Engineering goes out to the world. But when the SAF needs ST Engineering, it will be there. By supplying to others, it could also build up capabilities that could benefit the SAF. Commercialisation and globalisation are not done at the expense of the SAF."

Stepping Out

Chairman Peter Seah is confident that the Group's current structure optimises ST Engineering's significant capabilities, enabling it for global success. And learning from the world is very much on the agenda, as much as selling to the world is.

"As ST Engineering grew, it was very evident that because of its size, capitalisation and skills, it was a company that was capable of exporting services and products around the world. It was also evident that many of our capabilities could be put to good use in the commercial area. It also became very clear that we would be forgoing lots of opportunities if we confined ourselves to

Commercial or military, the same quality goes into all services and products of ST Engineering.

A Complex Relationship

"The defence industry grew very fast in terms of structure, expertise and revenue," said former Chief Defence Force Lieutenant-General (Retired) Ng Jui Ping. "Their ability to understand client needs, especially through input from uniformed officers, was vital. This was necessary even though procurement of equipment and supplies was handled by the MINDEF civilian structure."

He explained that it was necessary for MINDEF to separate end-users from negotiators to ensure a fair tendering process.

"It is a very significant achievement for our defence industries to develop in the way they did in a relatively short time. They grew from being directly or indirectly a transferrer of other countries' defence system intellectual property to producing homegrown defence solutions – with their own intellectual property – that were especially suitable for the needs of the SAF," he said. "The SAF has its own envisaged theatre, methods and strategies of warfare. The defence companies did their best to give the SAF what it needed.

"In principle, the SAF has no reason to favour a Singapore company over a US or European one, for example. The SAF wants the best value for money in meeting the General Staff's specifications determined to be necessary for the SAF in each and every defence solution.

"Obviously, the Singapore defence companies want to get the most business in the short and long-term from the SAF. The only way to do that is to develop capabilities and products that are better than other countries' solutions, and at the best price.

"The more certainty there is for the defence industries, the more willing they will be to invest in research and corporate tie-ups with other established and reputable defence companies in the world to transfer technology to Singapore. They will also then be able to hire and develop more and better people to produce better solutions for the SAF – provided the SAF is willing to buy these solutions.

"So in fairness, there is some limit in the defence industries' ability to invest, nurture and grow capabilities. Even so, there is a high level of cooperation and a sense of togetherness when our defence industries work with the SAF.

"This is especially so in the niche areas where the SAF's needs might be radically different from those of other forces around the world. It has also become clearer that technology is vital in helping the SAF to overcome its challenges, such as adverse manpower ratios. The SAF's systems must be clearly superior in technology.

"From the point of view of confidentiality and the unique characteristics of the operations we will conduct, it is a logical conclusion that the best solution for the SAF would be for critical parts of the systems and solutions to be done in-house by a Singapore company. Once you reach this conclusion, it becomes the unwritten duty of the defence leadership to help the defence industries arrive at this competence – having due regard to the laws of the land.

"So, as in so many things in Singapore's history, whether it is public housing, transport, foreign investments and so on, we've come to realise that we need our uniquely Singapore method to give us the best outcome."

"We recognised that the various capabilities led to synergy among our core business areas. Sometimes the total package is more important than the parts. Take electronics, for example. It is an overlay throughout the aerospace, land systems and marine sectors. Each part augments the others. It is one of the basic strengths of ST Engineering."

– Peter Seah

Singapore," he said. But growing markets was not the only reason ST Engineering is going out to the world.

"You go forth, first exporting skills and services, and as you go overseas, you get the opportunities to acquire more skills and companies to strengthen the Group. And some of these are dual-use technologies that can be reapplied to our defence business. This is so especially when you deal with high technology. We have invested and introduced lots of new capabilities – one of the best-known to the public is the fever screening system during the Severe Acute Respiratory Syndrome (SARS) crisis."

The groundwork for going global began when the ST Engineering Group was being restructured. It made ST Engineering's leadership more aware of how capabilities in the different sectors complemented each other, giving the Group a unique selling proposition – integrated solutions.

"We recognised that the various capabilities led to synergy among our core business areas. Sometimes the total package is more important than the parts. Take electronics, for example. It is an overlay throughout the aerospace, land systems and marine sectors. Each part augments the others. It is one of the basic strengths of ST Engineering," said Mr Seah.

But how would this bring customers to Singapore? How could they buy from Singapore if their local laws did not allow them to do so? The Group's capabilities had to be taken to the customer's doorstep. The Group would go global by going local.

"Setting up in the US took many years for us to understand the terrain but it has paid off," said Mr Seah. "The early years were tough. Our breakthrough came with the trials for the Bionix. We lost that, but realised that if we wanted to seriously get into the defence market in the US, we should have a stronger local presence with a strong team on the ground. That led to VT Systems being set up and getting John Coburn on board. That really helped to launch us in a very big way. Acquiring Halter Marine was also a significant milestone in our US development. After that, the rest followed."

China, however, requires a different approach and is no less challenging than the US market, noted Mr Seah.

(Above)
President Nursultan Nazarbayev of Kazakhstan (with cap) enquiring more about the SAR21 before a hands-on trial during his visit to ST Kinetics in November 2003.

"It's a country that needs a lot of time to understand and develop the right modus operandi. We've gone into aerospace there and a joint venture for dump trucks and so on. China holds tremendous potential, but it is not going to give very attractive returns in the near term. In the long term, however, China is an attractive market."

Not all opportunities are immediately obvious. Mr Seah gave the example of Kazakhstan.

"We had a colleague who had some knowledge of the country. He heard that they might be looking for a partnership in their defence industry. After the break-up of the Soviet Union, they thought they might want to rebuild their defence business. They were left with a lot of tanks, for example.

"So we went to explore that opportunity and met the President of Kazakhstan. We set up an office there and now do some consulting work. It demonstrates the versatility of ST Engineering's engineers. We don't just make guns, we can also do training and we're particularly strong in delivering military training through multimedia – we do jet fighter simulators, after all."

Home Base Singapore

Barry Desker, Chairman of ST Marine and Director of the S. Rajaratnam School of International Studies, agreed that it was essential for ST Engineering to extend operations overseas.

"We will increasingly be not just looking for business from abroad, but will have to either build new yards or acquire or take significant stakes in yards overseas, especially in the Asian region – China, India, Vietnam and Indonesia, for example, if the opportunities arise. ST Marine is also looking at businesses related to our core shipbuilding capabilities."

He emphasised that even though ST Engineering had to go out to the world, a significant part of it would have to remain local.

"Even though we are expanding overseas, Singapore is still the key to the business future of ST Marine – and if we take a broader view, ST Engineering. It is a Singapore icon, in the way that Singapore Airlines is, and while we may have global reach, we are also rooted in Singapore.

"I would say that as long as the defence industries are a significant source of revenue for ST Engineering,


Cybermatic
Hackney

we will have a very significant presence in Singapore and Singapore will continue to be a very important part of the iconic structure of ST Engineering. This is because we are identified with other products seen as Singapore products and because Singapore has achieved a reputation for uncompromising quality, on-time delivery and cost-consciousness. We benefit from this association."

A Global Workforce

Lim Ming Seong, Chairman of CSE Global Limited and one of SEEL's first General Managers, said that, to get a global footprint, a corporation has to be everywhere, with significant operations, not just marketing offices. Even joint ventures are good. But the acid test of a truly global company is in its human resources.

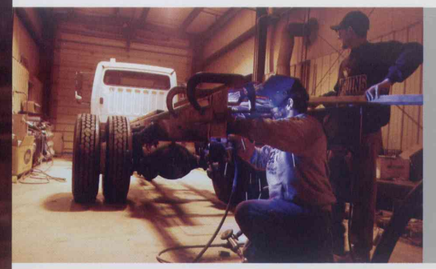
"Are your human resources today global? How much control does your home office have? Are overseas offices tightly controlled? Do you put 'your' men there?" he asked. "Or do you recognise that the foreign CEOs and CFOs running the acquired companies are all part of your system, your people too? Do people have cross postings abroad for learning and development? Are your people's resumés worldwide?

"My ideal is that if I recognise a Singapore CEO as good, I can post him anywhere in the Group. If I find a US CEO is good too, I can also post him anywhere in the Group. That's the challenge. Take Hewlett-Packard, Nestlé, Shell and Philips as examples. Their people can go anywhere. No lines drawn. No 'them' and 'us' between home office staff and foreign staff. How does HR track and evaluate the progress of everyone around the world consistently?

"These are the challenges if ST Engineering wants to be a truly global multinational company."

Winston Tan, one of ST Engineering's Board members, agreed. He noted, "There are very few truly global companies in the world. Many of them are really just corporations with operations around the world. An American bank like Citibank is really an international US bank, not a real multinational. Do they absorb a lot of people from around the world at all levels?

"Being world-class is also not just about being big, but having quality. When you look at a world-



(L to R)
Today, ST Engineering's operations span the world with a global workforce.

class company, it is defined by world-class quality and world-class products.

"The single biggest challenge is to build a world-class A-team. ST Engineering has been working on this. We have an American team, a Chinese team and are starting a European team. How do we integrate them? Will they all be able to transcend geographic and cultural borders to come together to create quality?

"Why do I say Singapore can do this? I've always described Singapore as being the US in a dot. We're so diverse, just like the US. That makes us really international in our thinking and our ability to understand such a vast range of cultures. It is a matter of time before Singaporeans become citizens of the world and able to communicate with so many across the globe. Look at our schools – we teach so many languages. Look at our soccer teams. We're a melting pot of races and cultures.

"If you go to Japan, you need to behave like the Japanese. In Singapore, you can be yourself – everyone from everywhere. The US is so vast, so not everyone gets to interact with this global mix of people, unlike here in Singapore."

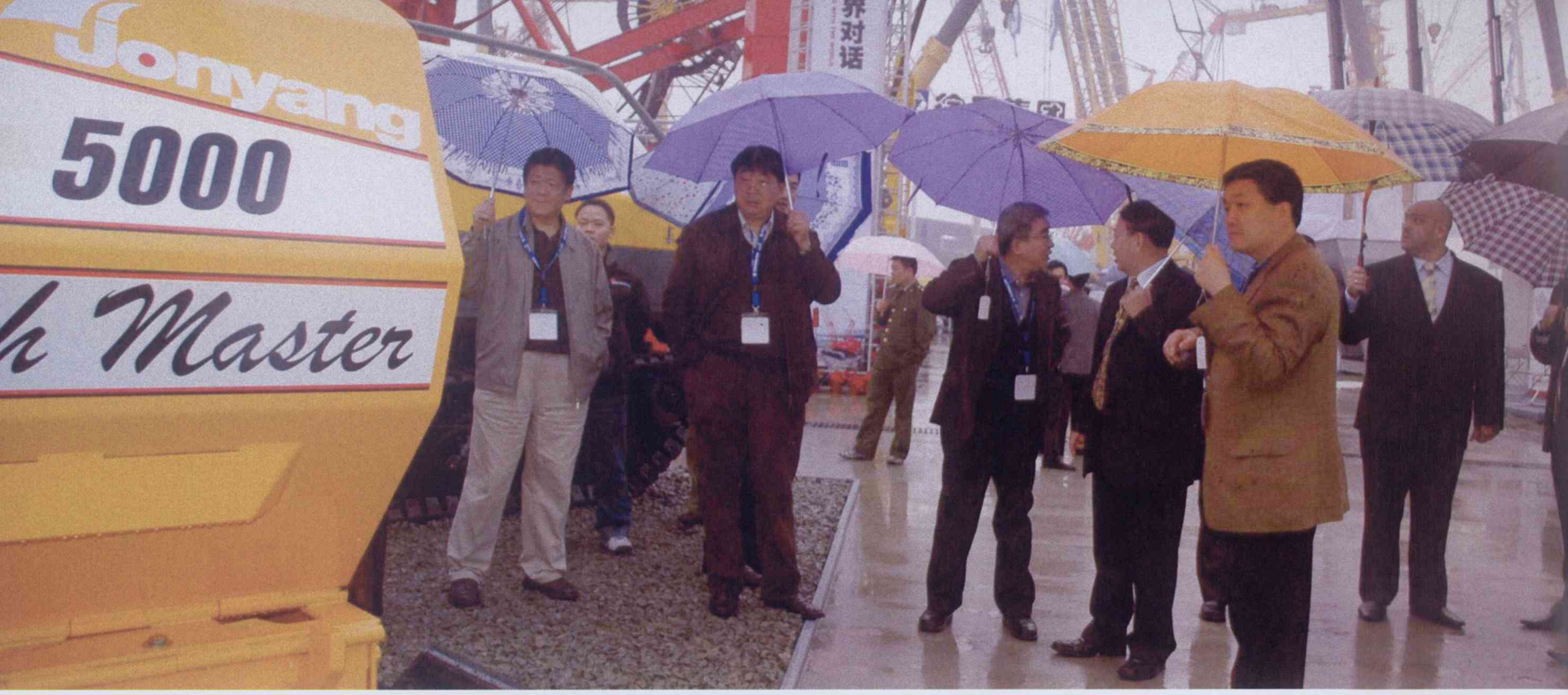
But it takes much more than first-class people to give an organisation a winning edge.

Developing People with Ideas

Hal Raveche, a VT Systems Board member, said that the only way to compete was to develop new products and services. No global A-team would be possible without people who could come up with unique and appropriate solutions for customers. And no organisation could last long without such creative, integrated thinking.

"You need products that change their domains or continue to improve. But companies are often slow to do this. They are more focused on improving profits and lowering the cost of operations. I think it is critical for ST Engineering's success to work at the creative end and create new products and services.

"There is a lot of competition, with lower-priced labour and better quality. There are also protectionist policies. To get past all that, you need to offer customers something they don't have or can't get. That's where the innovation comes in.



(Above)
VT LeeBoy road construction equipment being introduced to China at BAUMA 2006 in Shanghai.

"I think ST Engineering is outstanding in systems integration. They are pre-eminent in this. To compete, they will need to send people for advanced graduate-level training, not just internal training. Systems designers must interact with the best from other companies in systems and systems thinking. They have to learn with professors who are in the cutting edge of systems. Systems engineering is a discipline to take seriously."

With technology advancing quickly and challenges like epidemics and climate change presenting problems on a global scale, innovation cannot take place quickly enough.

"But having said that, we try to stay in focus," said Chairman Peter Seah. "We won't do everything under the sun. Essentially, ST Engineering is still a defence group. We have a very strong commercial business that rides on many of our core defence skills."

On Solid Ground

Tay Kok Khiang, President of ST Aerospace, said it was not group policy to hype future ideas and dreams. For him and the people of ST Engineering, solid achievements lay the groundwork for the future and give good reason for hope.

"We hope for the future," he said. "We're continuing to evolve our global network because this gives us our competitive edge. We will look into other areas, even those where we already are. It need not be in new countries but it must be based on purely business, economic and competitive requirements. We're not going to be everywhere for the sake of being everywhere. But we do want to be a dominant and significant global player.

"We'll build on our total services model to add new capacity in both the military and commercial areas. It could be a complement to Maintenance-By-the-Hour or a newer type. We will add capacity for specific platforms, and we will invest to realise that for components and engines. For example, next year, we will have the capacity to handle the CFM56-5B engine. We will definitely want to maintain our leading position in MRO. And that means acquiring new customers and serving existing ones better.

"Outsourcing by airlines is another major trend. In the past, they started in-house MRO because it

"By value engineering, we are referring to how we can further improve our current line-up of specialty vehicles. For example, our US-made vehicles would need to be metricised and perhaps simplified for them to be produced in China ... On the other hand, our China-made vehicles would need to be certified to Western standards and incorporate more advanced features for them to sell well in the Western countries."

– Sew Chee Jhuen

was hard to find good suppliers. It was conservative and safer to do it themselves. But the trend, which started around 2000 in the US, was driven by two considerations: having in-house MRO creates a higher cost structure and low-cost carriers using outsourced MRO were putting pressure on the traditional airline operators.

"There will also be an increasing requirement for new freighters – Boeing 757, Boeing 767, Boeing 777, A320, A330 – so even development work will evolve and grow.

"One thing we're not certain of yet is a trend to use Total Aviation Support services. If this does happen, we will be in a strong position as we have the capabilities to do this and a proven track record already.

"Another trend is the evolution of the Original Equipment Manufacturer (OEM) model for customer support. It is a complex issue now with no simple direction. Historically, OEMs did not do the maintenance of their own aircraft – they were too busy making new ones. Maintenance showed little profit.

"In the 1990s, General Electric tried and other OEMs followed. This resulted in loss of profits and high overheads. Then, in early 2000, GE decided to focus on intellectual property and spares. Others like Airbus followed. Maintenance was not their core business. So they will all need service providers who will do this for them with the required quality."

Adding Value

For the land systems sector, Sew Chee Jhuen, President of ST Kinetics, discussed the strategy to better integrate the specialty vehicles business of its US and China subsidiaries.

"We're working on this in three areas: value engineering, global sourcing, and global sales and distribution.

"By value engineering, we are referring to how we can further improve our current line-up of specialty vehicles. For example, our US-made vehicles would need to be metricised and perhaps simplified for them to be produced in China for sales in China and the rest of the world. On the other hand, our China-made vehicles would need to be certified to Western standards and incorporate more advanced features for them to sell well in the Western countries.

(Above)
ST Kinetics' subsidiary, GJK, displaying its range of products in BAUMA 2006, Shanghai.

In between, we are leveraging our engineering depth in Singapore to work with both the US and China entities to come up with innovative products to fill the product gaps that currently exist.

"On sourcing, our US companies have not ventured much out of the US to look for suppliers, so we're helping to take them to China, India and Eastern Europe to look for lower-cost supplies and subsystems. As a Group, we're looking to aggregate purchases for better prices. We are also looking into commonalising subsystems and parts and reducing part counts for better sourcing volume and lower inventory holdings.

"For global sales and distribution, we're already synchronising all our dealerships and finding new ones to expand our network. Previously, our China partners were only selling their products in China. We now export to many countries and expect the export volume to go up as more of our products get certified to Western standards. Similarly, our US products used to be very US-centric. We are now beginning to export them outside of the Americas. One other thing we are doing is to get our US entities to cross sell their China counterparts' products into the Americas through their network, and the China entities to do vice versa within China.

"Our goal for specialty vehicles is to create a line of niche products that not only meets the special needs of our customers but helps them to raise their productivity. For this, our products must be user friendly, reliable and easily supported. At the end of the day, we want to build a global brand for our specialty vehicles, synonymous with productivity and value for money."

Partnering Possibility

Seah Moon Ming, Deputy CEO of ST Engineering for Electronics & Land Sectors, as well as President of International Business and President of ST Electronics, feels the spectrum of possibilities in electronics is so wide, no single company can do it all alone. Finding the right opportunities to focus on is part of the challenge.

"You must dare to act quickly when opportunities arise. And you have to know what to build. It is important to develop core competencies in the area and secure the intellectual property rights. You can't do everything, but anything you make, you must be able to call it your own.

"You must dare to act quickly when opportunities arise. And you have to know what to build. It is important to develop core competencies in the area and secure the intellectual property rights. You can't do everything, but anything you make, you must be able to call it your own."

– Seah Moon Ming

"If you can't do it all alone, you have to work with partners. Sometimes you need help and it's good to share strengths to win deals. We need to embrace partnership.

"It's also vital that you know who to sell to. You have to then build a close relationship with your customer."

It sounds simple, but success or failure hangs on a company's ability to identify the right opportunities, the right partners and the right customers. ST Electronics' ability to make the right choices has resulted in them being the biggest systems integrator and the top ICT (Information Communications Technologies) company in Singapore. In the region, they are noted particularly for their strength in railway electronics. In satellite technology, Mr Seah reckons ST Electronics is among the top three companies in the world.

What the World Needs Now

On the land systems and solutions front, ST Kinetics is pushing ahead in a few technology areas including clean and green technologies.

"There is much concern these days on the environment," said Mr Sew. "ST Kinetics is a founding partner of the Fuel Cell Community in Singapore looking into renewable and other more efficient ways of using energy as part of our Clean and Green Energy initiative.

"We have been exploring electric and hybrid electric vehicles for a few years now. Given the high price of oil, it makes a lot more sense now to incorporate such technologies into our vehicles. Besides launching a hybrid airport tow tractor for use in Changi Airport, we are now building a hybrid electric excavator in China. There are lots of stops and starts in a typical excavator usage profile. We studied the usage patterns, built a prototype and proved that our solution is 20 per cent to 30 per cent cheaper to operate. For higher tonnage vehicles like terminal prime movers for sea ports, our engineers are now looking at hybrid hydraulics solutions to match the higher demands for such vehicles."

Seah Moon Ming said, "e-Government systems and solutions and managed services is an area we intend to expand in. We developed, for example,


HAVELOCK RD
ERP IN OPERATION
4.5m
EXIT 2
ERP
AHEAD
KEEP
SPEED
LIMIT
80 KPH
Havelock Rd
KEEP LEFT
REDUCE
SPEED
NOW

(Above, L to R)

1. A digital animation series – *The Future is Wild*.
2. A digital animation movie, *The Ten Commandments*, launched in 700 theatres in the United States.
3. Dogfight simulation by MÄK Technologies.
4. An animator sketching his characters for ST Electronics digital animation projects.

(Opposite)

Traffic management and electronic monitoring advisory systems keep traffic flowing smoothly in Singapore.

Internet portals for Singapore's National Servicemen in 2001, and have done projects in Botswana, China (including Hong Kong and Shenzhen), Kazakhstan, the Maldives, the Philippines, Japan, Thailand and of course, Singapore.

"Given the heavy bandwidth applications such as multimedia and video broadcast, and 3G becoming more prevalent, the demand for wireless broadband network solutions will grow. In developing countries, the telecommunication infrastructure network is inadequate to cope with the rising demand. You need more bandwidth, network management and optimisation. With the iDirect and Agilis brands marketed by us, we are now able to provide a more complete range of satellite communications products to our customers.

"Of course, we've been providing intelligent transport solutions for more than a decade for rail and road management in Singapore, and have moved into Taiwan, China, the Philippines, Thailand, and now Turkey. I believe we are one of the leading players in the world. But for that, you need to be financially strong."

Sometimes, one's own financial muscle is not enough. To meet the needs of customers worldwide, even a powerhouse like ST Electronics must have partners.

"To expand global markets rapidly, we need to establish strong tie-ups with foreign partners, for example, with Marubeni for railway electronics and with Hewlett-Packard for e-Government solutions. That way, we and our partners can all have a bigger slice of the pie," said Mr Seah.

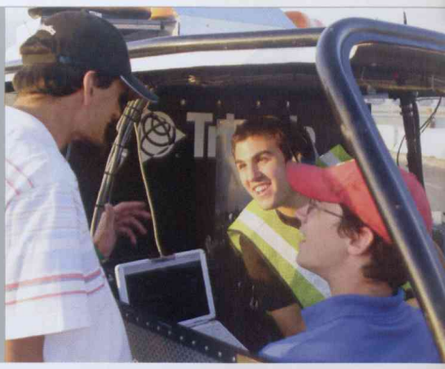
The Future Looks Good

One bright surprise in ST Electronics' future is in digital media and animation. In an industry where products are invisible (like software) or very small (a book's RFID, for example) or so large people do not see them (as in a traffic management system), ST Electronics' foray into digital media and animation is a rainbow splash of living colour.

"But it is not new and certainly not surprising," said Mr Seah. With 20 years of expertise in developing simulation training technology, ST Electronics was developing high-quality interactive computer graphics

"The company will look into some emerging technology areas which we think will present opportunities for further innovation. These are telematic applications, miniaturised sensors and edutainment technologies."

– Seah Moon Ming



(Above, L to R)
1. A multimedia and educational lab in a school in Kazakhstan.
2. Team members from ST Kinetics and Cornell University rigging up the Spider for DARPA Challenge 2005.

(Opposite)
The fully autonomous robotic Spider being put to the test in the desert during DARPA Challenge 2005.

used in training and gaming. Digital animation is an area that ST Electronics has delved into since 2004.

"It was a logical progression as we have been involved in computer graphics generation for simulation technologies," said Mr Seah. "This is an area in which we expect to grow – and there is a growing market today. In the early years, ST Electronics worked on several interesting projects including a visualisation walk-through for the Singapore Science Centre, and Weaveglow, an online game for the Ministry of Education.

"With the opportunities now created for commercial animation applications, we want to be an active participant in that growth. Our partners include Weta Workshop from New Zealand, best known for their parent company's work in the *Lord of the Rings* trilogy; Nelvana, a Canadian entertainment company; and movie maker Promenade Pictures. Our animators have produced animated movies for these companies, such as *The Ten Commandments*, *Jane and the Dragon* and *The Future is Wild*, and we are expecting more this year."

These, however, are established trends, and knowing what to invest resources in is a big part of a company's future success.

Emerging Technology

"The company will look into some emerging technology areas which we think will present opportunities for further innovation. These are telematic applications, miniaturised sensors and edutainment technologies," said Mr Seah.

"Telematic applications are the integration of telecommunications and application software. A common example is the use of the Global Positioning System with computers and mobile communications technology.

"We are the world's leading provider of motion sensors. We are looking at integrating various sensors with our ICT systems to give users comprehensive situation awareness, remote sensing and control. An example would be their use in combat. You can have thousands of miniaturised sensors dropped into an area to give you information on the area that you

might otherwise not be able to 'see'. Today, even the best-equipped infantrymen cannot see more than a number of kilometres ahead of them. Our challenge is to make solutions like ours cost-effective and more functionally powerful.

"Edutainment technology is an emerging area too, and with our sophistication in 3D modelling and simulation techniques, we can offer richer effects and content for edutainment. Integrated Digital Media is increasingly important in the classroom and is one of our key growth areas."

AI, Robot

At the land systems end, Mr Sew sees robotics as a key area to grow into next.

"From man-pack size robots to vehicle size unmanned platforms, we have experimented with many aspects of robotics to push our understanding in this area. To further our knowledge, we competed in DARPA Challenge 2005 with Cornell University. We rigged up our Spider Light Strike Vehicle to race across the desert autonomously. We advanced into the final, but a GPS problem cost us the race.

"This year (November 2007), we are again part of the Cornell University team in the DARPA Urban Challenge. For this race, the autonomous vehicle will have to work with traffic signals, pedestrians and other cars. This will take robotics to yet another level and I will be pleasantly surprised if any one competitor makes it to the end this November. It is much more difficult creating a fully intelligent land robotic vehicle than a flying or submersible one.

"The point here, like in most things we do, is to develop dual-use technologies. In this instance, anything we learn from robotics can be put to both civilian and military use. However, I think it's still a way to go before people can accept a driverless cab!"

Military Customisation

These days, it is tough getting what you want off the shelf, especially in the world of defence engineering. Because of high developmental and manufacturing costs, the industry often cannot offer much more than a standard version with some options.

"Many military forces in the world are becoming like the SAF in that they do not buy products off


EXIT
40mm AMMO

"There are also interesting developments in the area of high-energy weapon systems like lasers and magnetic guns. A ship equipped with such weapons would present a different kind of threat and we are watching developments in this area closely. We will take the necessary action to design a ship to carry systems like these if such weapons are built and deployed."

– See Leong Teck

(Opposite)
1. Ng Joeh Peng, Vice President, Kinetics Marketing Group, ST Kinetics (left) briefing B.N. Kalyani, Chairman, Kalyani Group (middle) during a tour of ST Kinetics' Visitor Centre. ST Kinetics signed a joint-venture agreement with BF Utilities, a company of the Kalyani Group, to set up a company to be based in Pune, India.

2. (L to R) His Excellency Risto Rekola, Ambassador of Finland to Singapore, and Dr Seppo Kääriäinen, Minister of Defence of Finland, talking to Wu Tzu Chien, President of ST Kinetics, during a visit to ST Kinetics in March 2006.

the shelf," said Mr Wee. "That's where we bring a set of capabilities to the table. We can integrate subsystems, take a customer's specifications and produce something. We can do this for customers prepared to work with us."

Mr Sew said, "ST Kinetics, along with the rest of ST Engineering, has been playing its part to help maintain the peace of Singapore through its portfolio of products. We see this as a key role and, going forward, will continue our efforts to enhance the effectiveness of the soldier. Besides Singapore, we are also putting increased emphasis on exporting our unique solutions to friendly nations, including developed countries."

Mr Wee gave some examples of such products.

"We have some innovative and cost-effective solutions that others want from us – for example, our 40mm munitions, where we are number one in the world. We make the Bronco and we are one of two major suppliers of articulated tracked vehicles in the world. Our SAR21 rifle is a world-beater and we've got a lot of traction from that. Our Pegasus heli-portable light gun is getting a lot of attention, as is our SRAMS, the 120mm super rapid advanced mortar system.

"Basically, as long as we get the formula right and stay customer-centric, that is, listen well and deliver, and have good people to keep us at the edge of innovation, we will do fine."

Rule the Waves

See Leong Teck, President of ST Marine, said there were even more radical trends for naval vessels. The future for the marine sector is certainly an exciting one for engineers.

"Today, our frigate is state-of-the-art. But in the future? What will be a more advanced weapon system? We have to keep a close watch on trends.

"For naval vessels, you can innovate in three areas: operational concept, stealth and speed.

"By operational concept, I mean something like the idea of an 'arsenal ship', something the US had talked about some years back. This is an unmanned fighting vessel that would have a different operational concept.

"There are also interesting developments in the area of high-energy weapon systems like lasers and magnetic guns. A ship equipped with such weapons

would present a different kind of threat and we are watching developments in this area closely. We will take the necessary action to design a ship to carry systems like these if such weapons are built and deployed.

"These are, of course, in the experimental stage. The power requirements of such a vessel would be tremendous and a vessel with these weapon systems would in effect be a small power station. The question would then be: how can such power be generated? Even now, with gas turbine engines, you can produce lots of electrical energy – perhaps even sufficient for a high-energy weapon.

"We already have the capability to build stealth ships. Today, any naval combatant craft must be stealthy."

ST Marine already boasts a good mix of capabilities, but is clearly keeping on its toes and watching trends closely to ensure that Singapore's protectors of our sea lanes will always have a technological edge.

No More Fog of War?

"Unmanned air, ground and sea vehicles will be an important area," said Mr Wee. "As more of these systems are deployed, operational concepts will have to change. It will be an evolving area of science. This is already true for manned systems like the Bionix. The first changes we made were to increase firepower and protection. Then we made it more networked so it could fight as part of an integrated force. All this is encapsulated into the latest SAF mantra: ONE SAF. How do we network all the different parts of a unified force? How do we get information from unmanned systems and feed it to all relevant units?

Sew Chee Jhuen, President of ST Kinetics (right), welcoming Yuan Zhou, Mayor of Guiyang, who was in Singapore to sign a Letter of Intent between the Guiyang district government and ST Kinetics, capturing the government's commitment to support ST Kinetics in growing its business in Guiyang, China.

"Is the HR outlook tough? Yes and no. Tough because the competition for people has grown more keen. But no, because we are conscious of the importance of people so we spend a lot of resources to develop them. We don't leave it to chance."

– Tay Kok Khiang

"With all that information coming in, you have to know how to manage it and make it usable to a commander or soldier so that they can make decisions. You've got to fuse all that information and make it quickly intelligible to the user. There is going to be less and less of what Carl von Clausewitz called 'the fog of war'. A hundred and fifty years ago, a commander might never know if someone was just behind a nearby hill. Now the battlefield is coalesced for the decision-maker.

"Another thing, of course, is artificial intelligence that can help us sort through all the information we get on the battlefield. But human input will still be vital, for example, in the rules of engagement, and experienced soldiers will know what to prioritise.

"Ultimately we want a global customer base. It will also give the SAF assurance that someone else buys it too! We want to have a reputation for innovation and quality.

"Many of our engineers are actively engaged in hands-on engineering. We need to keep them up to date, challenge them, encourage sharing of ideas among them, leverage on the defence ecosystem and intellectual property from elsewhere. It is a virtuous cycle and that is the kind of conducive environment we want."

People Investment

But for a future of unmanned combat vehicles and artificial intelligence, the present and near future require the abilities of first-class people.

Mr Tay of ST Aerospace said, "We will be investing more in training and development for our employees. After all, it is the people who do the job. People count. Right now, we have between 500 and 600 new employees being trained around the world every year. This is a serious investment and commitment to the future. We must build the engineering workforce. It gives a good competitive edge in both management and building the capacity to create more complex solutions.

"Is the HR outlook tough? Yes and no. Tough, because the competition for people has grown more keen. But no, because we are conscious of the importance of people so we spend a lot of resources to develop them. We don't leave it to chance and try to

(Above)
ST Aerospace celebrates with Boeing and FedEx Express, the 2,500th aircraft delivery to FedEx.

recruit from the market, though it is cheaper that way. We have to be sure, so we provide our own training and development."

Mr Tay said top-flight personnel are vital because of global trends in aerospace.

"First of all, aircraft have grown more complex. That's true of military platforms, but this is increasingly true of commercial platforms too. We're in a good position, with a set of capabilities no other MRO company or airline possesses.

"Second, more aircraft have more composite content. For example, the new Boeing 787 and A350. Again, we've been dealing with composite materials from our military days, so we're well-placed to handle this. Our share of the EC120 helicopter, for example, is almost entirely composite."

Flat World Challenge

Mr Seah agreed that top people were also a priority for ST Electronics.

"That's going to be our major challenge – talent management and retention. In five to ten years, it is going to be a 'flat' world where we're globalised to a large extent. It is going to be borderless. People have become more overseas-oriented and more mobile.

"Until recently, our Singapore staff was home-bound and reluctant to move overseas. In five years, we're going to need more global citizens to be deployed around the world. We have acquired many foreign companies – how do we integrate them and their staff? We need cultural integration too, besides the integration of systems like HR, finance and business."

But in tomorrow's world without boundaries, there lies a happy solution – the very technology that ST Electronics develops will give it access to a talented workforce almost unrestricted by time and space. In a world where business (as Bill Gates put it) can be done at the speed of thought.

A Macro View

The Group has changed more since 1997 than at any other period in its 40-year history. But the rapid rate of change reflects the pace at which the world and technology have been changing. ST Engineering is

(Above)
Tan Pheng Hock with judges and winners of the Safety@Work Creative Awards 2007. The Awards are jointly organised by the Ministry of Manpower and ST Engineering and are ST Engineering's corporate social responsibility initiative.

keeping pace and CEO Tan Pheng Hock wants to make sure that the Group is always a few steps ahead.

Integration

"There are still some areas in which we could improve the integration for more synergy," Mr Tan said. Integration has certainly helped ST Engineering, but its potential is also matched by its challenges.

"As technology gets more sophisticated, it gets more difficult for just one of our SBAs to have a total solution for a customer. We still need more capabilities in niche areas, but capabilities that are 'cross-SBA' are going to be more important.

"Global integration of HR policies is also still not there yet. Of course, when we're looking at corporate governance or control, the whole Group needs to be integrated and needs a universal set of standards. But in other things, we do appreciate that local ways of doing things might well be exactly what is needed and so we allow the diversity.

"We still need a multinational talent pool that is geographically mobile. We still do not have a mixture of nationalities in all our locations. To do this, talent needs to know how to deal with different cultures. Right now, there is no cross-cultural diversity exposure. And this is why it is now required for an executive to have served overseas for exposure before being promoted to the next level.

"This means our leaders will have been rotated through more than one SBA and more than one geographical location. To be a global company, you need global experience for local effectiveness. We're starting with sending the Singapore side out first and then later bringing our overseas talent to Singapore."

Building a globalised talent pool offers clear challenges in the years ahead. What is more, that talent pool must be able to move quickly, stay nimble and be a consolidator instead of merely reacting to market changes.

Making Things Happen

"ST Engineering must be able to drive market change. It must be the agent that will reshape the business environment. It must take the initiative and be proactive," said Mr Tan.

"We want to be in a position where we drive change instead of having change drive us. I think we have the mental preparedness and the means to do so when the time comes. Moving forward, our model is one of us making things happen."

– Tan Pheng Hock

"Technology moves so fast. Cycles are shorter than in the past, so while a product can last 10 to 20 years, its electronics system, for example, has a shorter cycle: one to three, three to five, five to eight. This means we need to be very flexible and very mobile. We need to sense the environment and move very fast, particularly in the electronics sector.

"More importantly, we need to adopt an approximately right approach and move ahead and refine and adjust as we move along. We can't wait for all the information to be available to make the decision, otherwise we will miss the boat.

"This is where, increasingly, we will need a cohesive team of local and foreign talent with diverse knowledge and expertise to give us a holistic perspective in guiding this approximately right approach.

"We want to be in a position where we drive change instead of having change drive us. I think we have the mental preparedness and the means to do so when the time comes. Moving forward, our model is one of us making things happen."

Aerospace Outlook

For aerospace, Mr Tan agreed with Tay Kok Khiang that the use of composites was a significant trend that would give ST Aerospace an edge. "It will shape how we do things," said Mr Tan.

The other trend he noted was how the industry has consolidated, with fewer aircraft makers because the development cost was so high. The industry is also shaping up differently, with Boeing wanting to sell total support for their aircraft from the onset. Maintenance cycles are undergoing changes too, as older aircraft are decreasing in number. There was also the increasing problem of airspace crowding and aircraft getting larger.

"But in any challenge, there are opportunities. Maybe Total Aviation Support will be more important. Airlines are reshaping and do not want to do maintenance. We are asking this question: What can we do to support or undertake the comprehensive maintenance of an airline's assets? How can we partner an airline in such a way that it allows them to focus on their core business? Without union issues, no capital outlay? And with greater flexibility?

Electronics Outlook

"Electronics' special challenge is that it is a fast-changing technology. There are many solutions created and often, it's a matter of who is faster to market and who can get accepted. Take VHS and Betamax for example, two home video solutions. Betamax was better but VHS got to the mass market first. So you can have the better solution, but can you get to market fast?

"And of course, would one country buy encryption technology from another for its armed forces? You thus need to play in the non-sensitive part of the environment. Whoever uses it will not feel that their security has been breached. One area, for example, is ruggedisation, making computers and peripherals tougher for field use.

"But electronics has also got far more scope for applications in everyday life in a wide range of industries beyond the military: simulation, games, air traffic control, ships, mass rapid transit trains and animation. The key is building a leading business in some areas, not all areas – for example, satellite communications and digital media."

Land Systems Outlook

"Because platforms are built to last a long time, the challenge is to better equip an existing one instead of buying a new one," said Mr Tan. "Engineers will have to work out how to spiral new technology into older platforms. They will have to look at life-extension solutions, if not customisation.

"There will be a need to better protect vehicles and troops. There are no good solutions now. Will operational doctrine change? If military could choose, they would certainly want to reduce their logistics tail. Could they go from 'just in case' to

ST Electronics signs an agreement to produce and invest in digital animation projects with Nelvana Studios of Canada in Cannes, France in April 2007.

(Above)
Meeting of minds with the Economic Development Board: Manohar Khiatani, Assistant Managing Director, Industry Development, EDB with Wee Siew Kim, Deputy CEO (Aerospace and Marine) and President Defence Business. Looking on are Goh Yong Siang and Lim Serh Ghee.

'just in time'? What sort of new solution would that require?

"Urban warfare is another challenge. Will it actually mean fighting in the streets from building to building? Can there be a non-traditional method to clear an area? Can we reduce human intervention in urban warfare?"

Marine Outlook

"The military, especially in the US, requires faster and faster ships for interdiction. And they need heavy payload capacity on top of that. With more homeland security issues, waterways need to be protected too. The US Coast Guard will need a bigger fleet.

"Oil rigs are going deeper and they need to be supplied. There will be a steady need for support vessels. But there is even more potential in gas. Oil is running out, but gas is an area really worth looking at. It is a good oil alternative."

Business Tomorrow

Mr Tan gave some idea of where ST Engineering is headed in terms of business strategy.

"As the world gets more complex and markets consolidate further, I see us playing in this arena through acquisitions and possibly more joint venture-type business models. It is getting too expensive to buy companies which are getting larger. Protectionism will still prevail in some areas, hence we need to be local in certain areas to gain access to those markets. This could be the way for us to create scale."

But the business environment of tomorrow need not be a totally cut-throat arena. Mr Tan reckons that 'co-opetition' – a hybrid of cooperation and competition – will become more common.

"We can compete in some markets with our competitors and cooperate in other markets. Increasingly, it is becoming difficult to be good in many technological areas. In our own commercial sectors, for example, we could be global leaders in some areas, regional leaders for others, or niche champions."

It will be fertile ground for joint ventures, cost sharing in development and the sharing of capabilities in the development of complex projects.

(Above)
Tan Pheng Hock (centre) at a reception with Al Trawinski, Program Manager, US Army Comparative Testing Programs, and Tommie Goh, Director of VT Systems, in 2006.

"Where you develop a niche or leadership in one or more areas, you have a value proposition for others to want to work with you. Systems and solutions will get more complex and could well be beyond the capabilities of any organisation working alone. We will probably see more cooperation and joint ventures, where scale and speed and innovativeness are going to be key."

The Shape of Things to Come

Just as important as the business outlook are the new trends in technology as well as the way business is conducted.

Mr Tan identified four trends that ST Engineering will have to keep in mind: the need for dual-use technology, the need for systems to be modular, the need to be green and the need to be small, light and mobile.

Dual-use Technology

"Commercial technology moves faster than military technology. The military leverages on this, saving money. So there is a lot of overlap and potential for dual use, except in some capability like stealth," said Mr Tan.

"There are many vehicles, designs, components and subsystems that you can buy off the shelf. They are cost-effective, readily available and tested. So we don't reinvent the wheel where an off-the-shelf system can be used in a solution. We integrate it or modify it before integration to better suit its purpose. The key is to be a smart user of technology which has already been invented.

"This reduces cost and increases the speed of development. Satellite communications are a good example. And of course, developments from the military side can feed the commercial side. There are lots of benefits in this cycle.

"There is no conflict. Instead, we have centres of excellence that focus on particular capabilities and apply them in all SBAs, both military and commercial. This gives us economies of scale in R&D. It avoids overlaps, leaving us more capacity in terms of money, people and equipment."

"ST Engineering has grown tremendously and it is still growing. But we aim to keep ST Engineering nimble and agile. We must keep that ability to respond quickly and flexibly to serve our customers and adapt to the business environment no matter how big we get."

– Tan Pheng Hock

Modular Design

Although modular design is not a new idea, it has not been optimised in the four SBAs.

"We will need to be more modular in our design and systems, creating or integrating systems that have more 'plug and play' compatibility. We need more commonality in the components and subsystems of our products. This will make them more user-friendly as it will give the same touch and feel from, say, one vehicle to another. This will result in greater ease of use and also lower costs of production. The lifecycle cost would also be reduced due to the commonality of parts."

Be Green

"Our products and systems will increasingly need to address environmental issues too," Mr Tan said. "They have to be environmentally friendly in their design. Emission reduction is one example."

Leading, said Mr Tan, requires understanding of what drives behaviour in the market. "In time to come, most products and systems must address this environmentally-friendly requirement. Users will demand lower power consumption in all systems.

"But being a green company does not merely oblige us to make environmentally-friendly products. Our own practices must be green too. We are users of resources and we need to be responsible about that.

"And it is not just emissions or other waste products that are my concern. Even noise can be pollution."

Small is Beautiful

"Our strength lies in speed of development, which should also be cost-effective," Mr Tan said. "Our special capabilities will enable us to be very good in some niche areas, particularly in turnkey developments that must be light, compact and with low manning requirements. Our Pegasus gun is a good example of this. It's compact, light and can be crewed by fewer men, but it is no less capable or lethal.

"At the end of the day, you adjust and even lead the change where the opportunity arises. We cannot hold back simply because we need to seize the opportunity to lead. Our time has come.

(Above)
Tan Pheng Hock in conversation with Ho Ching, Executive Director and CEO, Temasek Holdings, and the first Chairman of ST Engineering.

(Opposite, L to R)
Seah Moon Ming (President, ST Electronics), Chan Soo Sen (Minister of State for Trade and Industry, Singapore), Lu Guang Lin (General Manager of Guangzhou MRT) and Wayne Liu (Chairman and CEO of Guangzhou-PCI) at the opening of Guangzhou MRT Line 4 in December 2005.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At ST Engineering's 40th Anniversary celebration event at its founding site, (from left) Peter Seah, Wee Siew Kim, Ho Ching, Tay Kok Khiang, Wu Tzu Chien, Tan Pheng Hock, See Leong Teck, Seah Moon Ming, Sew Chee Jhuen.

ST Engineering has reached a level of maturity where it is no longer unthinkable for the Group to be a leader in areas where the market has not yet evolved.

"Our innovations reinforce our thinking that we have the right processes and approach in nurturing ideas in our Group."

Force Multiplier

Mr Tan is confident that ST Engineering's systems are flexible and nimble enough to see the Group through many business cycles. Equally important is the multiple-industry applications of its current technology.

"In our commercial business, you will see multiple industrial applications of our technology. We have multiple touch points through multiple products and services operating in multiple geographies. This will minimise risk and also allow ST Engineering to run as an integrated Group.

"In the military arena, we are treading new ground like the unmanned systems which are not readily available. With our creativity and development mindset, we can be a leader in these areas."

Look Ahead

"We want to be a leader, not just a player. We can be in the forefront of change, the way of things to come.

"Aerospace is there with the MRO business but it may need to move beyond MRO. It has gone, for example, into pilot training. Electronics' satellite communications make the company one of the world leaders. Kinetics has a number of products that are leaders in the North American market. The challenge is to grow them beyond North America. Marine may not build Very Large Crude Carriers, but can be very good in certain specialised areas.

"ST Engineering has grown tremendously and it is still growing. But we aim to keep ST Engineering nimble and agile. We must keep that ability to respond quickly and flexibly to serve our customers and adapt to the business environment no matter how big we get. We need to sense the ground. This is why local effectiveness is very important.

"You will see us as an organisation that uses our technology, systems and products to save lives, as in the Infrared Fever Screening System during SARS, and in the LST and Bronco during the Asian tsunami rescue operations and our homeland security solutions to deter terrorism.

"So yes, we have our challenges but we also have our core values that have withstood the test of time. Integrity, value creation, commitment, courage and compassion – these will always be in all we do, what we promise. Before trying to do something right, we want to be doing the right thing! That is our first fundamental.

"I am very grateful to the founding fathers, the leaders who laid a solid foundation for ST Engineering to thrive. It was this strong foundation that has helped ST Engineering grow to become the global organisation it is today.

"It is now the job of the senior management team to lay the foundation for the future leaders of ST Engineering, to bring it to greater heights.

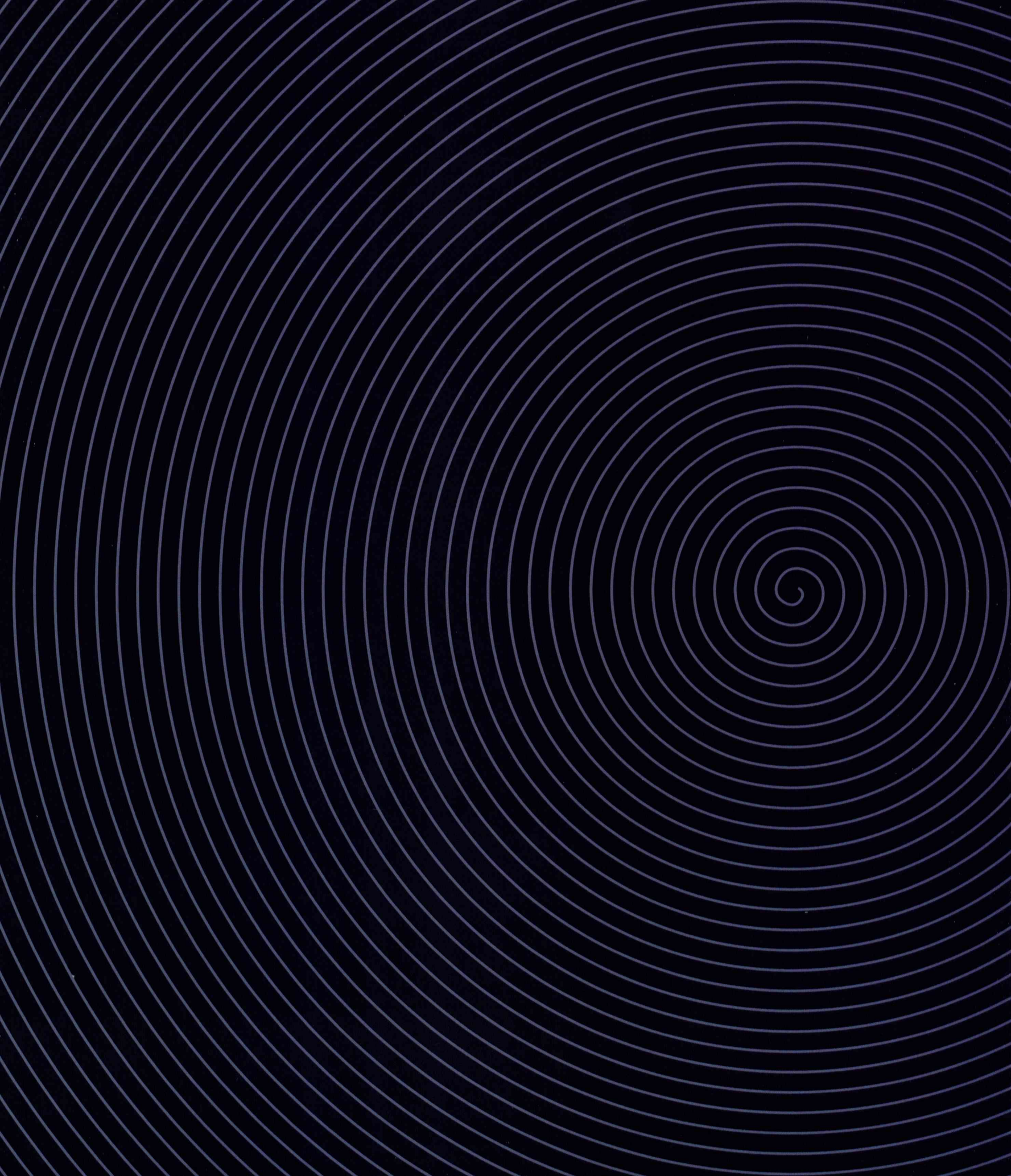
"The future is for us to make."

Glossary

AED	Air Engineering Department
AES	Aerospace Engineering Services
AGL	Automatic Grenade Launcher
AMC	(US) Army Materiel Command
AMM	Aircraft Maintenance and Modification
AOG	Aircraft-On-Ground
AOS	Allied Ordnance Company of Singapore
ARL	Airline Rotables Limited
ASEAN	Association of South-East Asian Nations
BAUMA	International Trade Fair for Construction Machinery, Building Material Machines, Construction Vehicles and Equipment
BZK	Beijing Zhonghuan Kinetics
CAD/CAM	Computer-Aided Design/Computer-Aided Manufacturing
CAI	Chartered Ammunition Industries
CAV	Commercial Articulated Vehicle
CET	CET Technologies
CETS	Component and Engine Total Support
CIC	Combat Information Centre
CIS	Chartered Industries of Singapore
DARPA	Defense Advanced Research Projects Agency
DMO	Defence Materiel Organisation
DSO	DSO National Laboratories (prior to 1997, Defence Science Organisation)
DSTA	Defence Science and Technology Agency
EDC	Engineering & Development Centre, ST Aerospace's inhouse engineering and development arm
EGPWS	Enhanced Ground Proximity Warning System
EIF	Exploration/Incubator Fund
ESEA	Eurocopter South East Asia
FLAMES	Fire Location And Management of Emergency System
FPSO	Floating Production Storage Off-loader
GIIHC	Guiyang City Industrial Investment Holding Corporation
GJK	Guizhou Jonyang Kinetics
GLC	government-linked company
GPMG	General Purpose Machine Gun
Hazmat	Hazardous Material
ICT	Information Communications Technologies
IFss	Infrared Fever Screening System
IFV	Infantry Fighting Vehicle

LAD	laser acquisition device
LDO	Limited Depot Overhaul
LEAP	Leadership Enhancement Portal
LRT	Light Rail Transit
LSS	Land Systems and Solutions, a division of |ST Kinetics
LST	Landing Ship Tank
LSV	Light Strike Vehicle
MAE	ST Mobile Aerospace Engineering
MBH™	Maintenance-By-the-Hour
MGB	missile gunboat
MINDEF	Ministry of Defence
MNC	multinational corporation
MRO	maintenance, repair and overhaul
MRT	Mass Rapid Transit
OBO	Operation Blue Orchid
ODE	Ordnance Development and Engineering
OEM	Original Equipment Manufacturer
OVM	on-vehicle-material
OWS	Overhead Weapon System
PAE	Panama Aerospace Engineering
PFS	Pacific Flight Services
RFID	Radio Frequency Identification
RoRo	roll on roll off (shipping term)
RSAF	Republic of Singapore Air Force
RSN	Republic of Singapore Navy
SAA	San Antonio Aerospace
SACO	Singapore Aero-Components Overhaul
SADC	Singapore Air Defence Command
SAE	Singapore Automotive Engineering
SAEOL	Singapore Aero Engine Overhaul Limited
SAF	Singapore Armed Forces
SAFE	SAF Enterprises
SAI	Singapore Aircraft Industries
SAMCO	Singapore Aerospace Maintenance Company
SARS	Severe Acute Respiratory Syndrome
SAS Component	a joint-venture component repair company between ST Aerospace and the Scandinavia-based SAS group
SASCO	ST Aviation Services Company
SAW	Section Assault Weapon
SBA	strategic business area
SCDF	Singapore Civil Defence Force
SDDA	STA Detroit Diesel-Allison
SDI	Singapore Defence Industries
SEEL	Singapore Electronic and Engineering Limited

SES	Singapore Engineering Software
SFI	Singapore Food Industries
Sheng-Li	Sheng-Li Holding Company Private Limited
SIA	Singapore Airlines
SNIAS	Société Nationale Industrielle Aerospatiale
SPRING Singapore	Standards, Productivity and Innovation Board, Singapore
SRAMS	super rapid advanced mortar system
SSE	Singapore Shipbuilding and Engineering Pte Ltd
ST Aerospace	Singapore Technologies Aerospace
ST E&E	ST Electronics and Engineering
ST Electronics	Singapore Technologies Electronics
ST Kinetics	Singapore Technologies Kinetics
ST Marine	Singapore Technologies Marine
STA Engineering	ST Aerospace Engineering
STA Engines	ST Aerospace Engines
STA Supplies	ST Aerospace Supplies
STA Systems	ST Aerospace Systems
STARCO	Shanghai Technologies Aerospace Company
STC	Singapore Technologies Corporation
STH	Singapore Technologies Holdings
STPL	Singapore Technologies Pte Ltd
SVS	Specialty Vehicles and Services, a division of ST Kinetics
TAS™	Total Aviation Support
TSS	Total Support and Services, a division of ST Kinetics
UAV	Unmanned Aerial Vehicle
VMV	Vision, Mission and Values
VSAT	Very Small Aperture Terminal
VT Systems	Vision Technologies Systems



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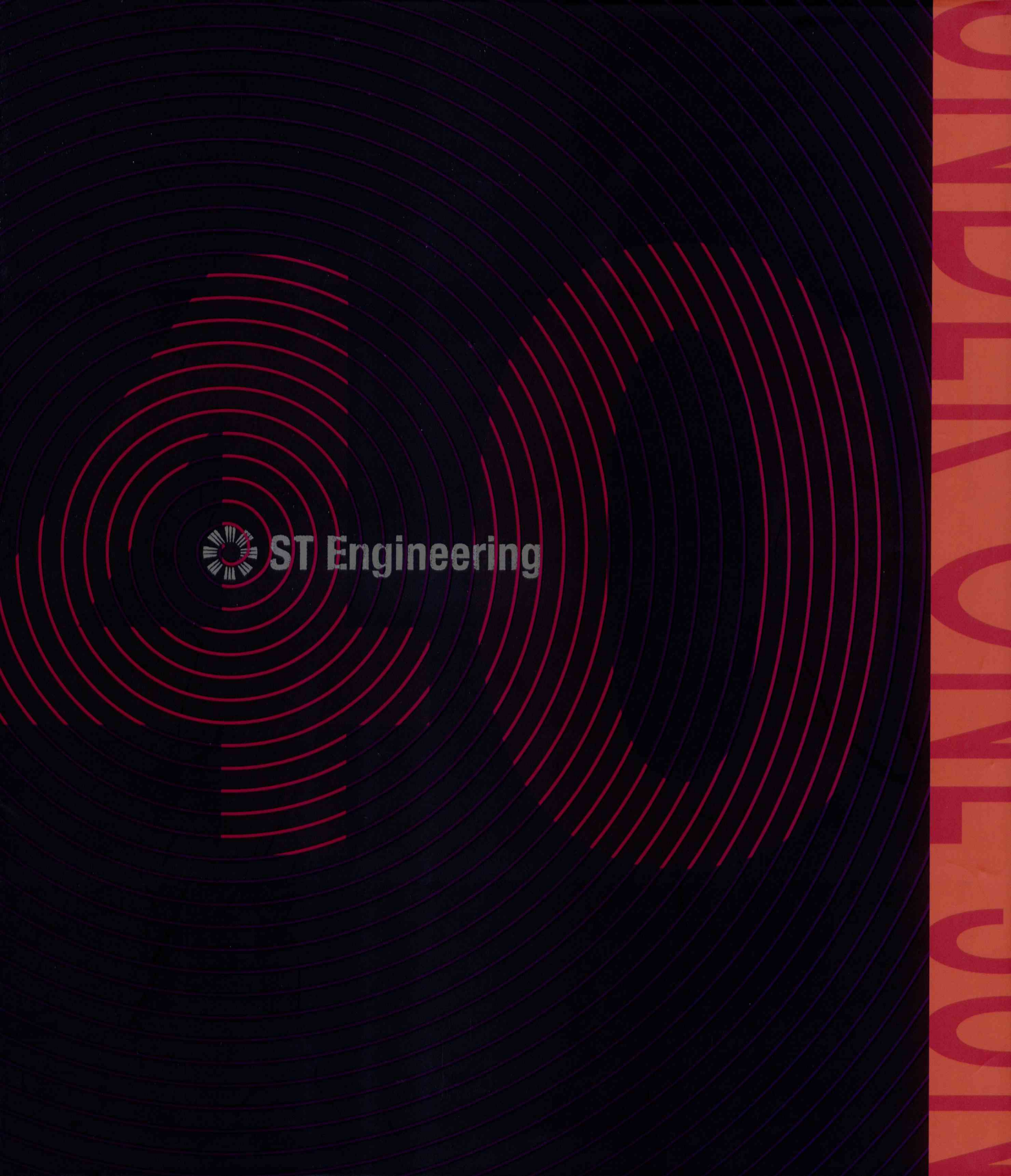
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