

# GLOBAL BUSINESS REPORTS

INDUSTRY EXPLORATIONS

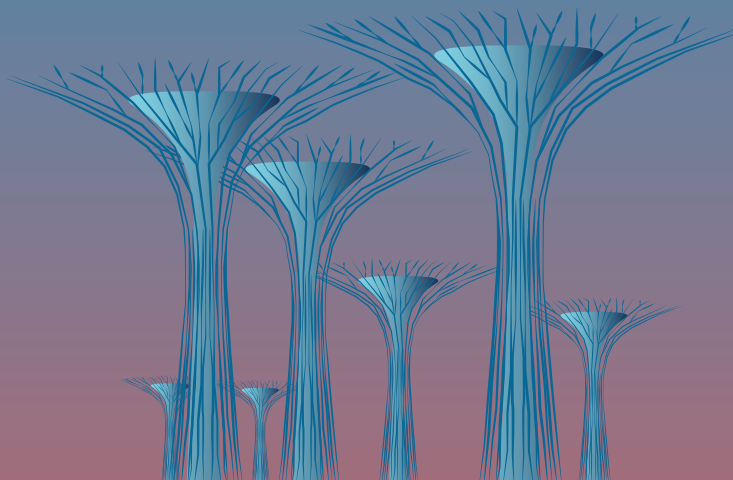


## SINGAPORE AEROSPACE

2017



*MROs - OEMs - Engineering - R&D - Aviation - Satellites*



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## Dear Reader,

This is the first time Global Business Reports has developed an aerospace report on Singapore. We are pleased to have worked with the team to showcase Singapore's strength as an air hub and the various industry players across the value chain within our aerospace sector. As you read through the pages of this report, we hope that it not only gives you a better understanding of the sector but also an idea of how Singapore can be your trusted location from which to write your Asia growth story.

In the span of time since Changi Airport first opened in 1981, Singapore has achieved a strong reputation as a Global Aviation Hub. With over 500 accolades, Changi Airport is widely recognised as one of the world's best international airports. Singapore Airlines has likewise become a widely known brand. Building on our strengths as an air hub, Singapore has developed a leading aerospace industry that includes manufacturing, engineering, research and development (R&D), maintenance, repair and overhaul (MRO), and other aerospace-related services.

Today, Singapore has one of the largest and most diverse concentrations of aerospace companies in Asia with over 130 aerospace companies making Singapore their home in the region.

As a leading MRO hub in Asia offering nose-to-tail aftermarket services, Singapore has built airframe maintenance, engine overhaul, structural and avionics systems repair, as well as aircraft modifications and conversion capabilities. These core competencies, coupled with our commitment to quality and safety, have made Singapore a recognised one-stop solutions provider for airlines' maintenance and repair needs. Aerospace companies continue to regard Singapore as their trusted partner in Asia and have invested in MRO capabilities for new generation platforms that will allow them to seize opportunities in the rapidly growing Asia aerospace market.

Leading aerospace OEMs and suppliers also offer a variety of other related services here, including fleet management, component and spares distribution, logistics, aircraft leasing as well as pilot and crew training. These, added together, make Singapore the undisputed leading aftermarket hub in Asia.

Beyond MRO and aftermarket services, Singapore is also looking to support the global aircraft production ramp-up by working closely with aerospace multi-nationals and local suppliers to build manufacturing capacity and capabilities here. We have achieved good success in aero engine manufacturing with leading OEMs including GE Aviation, Pratt & Whitney and Rolls-Royce. This

has been coupled with the presence of a growing base of both local and multinational aerospace suppliers such as RLC Engineering and Singapore Aerospace Manufacturing (SAM).

Many companies have cited Singapore's strong manufacturing base, skilled manpower and focus on science and engineering as reasons for setting up manufacturing activities here. The burgeoning aerospace R&D landscape in Singapore, that taps into our existing strengths in science and technology research capabilities, further allows companies to leverage industry-aligned research institutes and universities as well as a growing pool of research talent to enhance their manufacturing and MRO activities through innovation.

With the increasing adoption of disruptive technologies such as robotics and automation, additive manufacturing, digital manufacturing and the emergence of new business segments such as unmanned aircraft systems (UAS), Singapore is also looking to partner with companies to grow their innovation capability and develop new business models here. Notably, in 2016, Airbus signed a memorandum of understanding with the Civil Aviation Authority of Singapore to conduct UAS proof-of-concept trials in Singapore.

These investments bear testament to Singapore's status as an established aftermarket services hub and a key aerospace manufacturing location that is innovation driven. Moving forward, Singapore will continue to expand and deepen our capabilities through supporting companies in building advanced manufacturing and MRO capabilities, equipping our workforce with relevant skills and encouraging the adoption of advanced technologies to enhance competitiveness in our local aerospace industry.

As a third of all new aircraft is expected to be destined for Asia-Pacific, there is an increasing need for aerospace companies to provide timely in-region support for their customers. We are confident that with Singapore's comprehensive MRO base, strong aerospace workforce and connectivity to the rest of the Asia-Pacific, Singapore will continue to be a prime location for aerospace companies to capture the growth opportunities in Asia-Pacific.

**Tan Kong Hwee,**  
Director, Transport Engineering, Singapore Economic Development Board



## Exclusive Interviews

Leaders from both the private and public sector delve into the nuances and nascent developments that are shaping the industry.

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and many more



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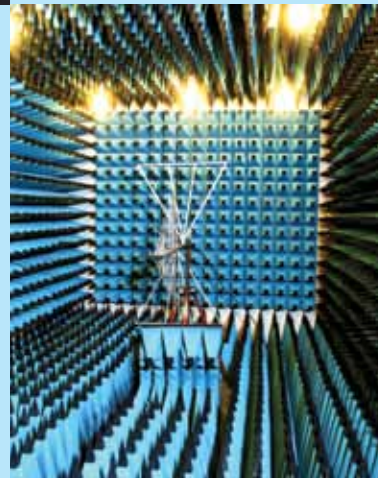
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## Singapore at a Glance

**Population:** 5,781,728 (July 2016 est.)

**Land area:** total: 697 km<sup>2</sup>

**Official language(s):**

Mandarin (official) 36.3%, English (official) 29.8%, Malay (official) 11.9%

**Head of Government:**

Prime Minister LEE Hsien Loong (since 12 August 2004)

**GDP:** \$296.6 billion (2015 est.)

**Growth rate:** 1.7% (2016 est.), 2% (2015 est.), 3.3% (2014 est.)

**GDP per capita (PPP):** \$87,100 (2016 est.)

**Source:** CIA Factbook

**Corporate Income Tax Rate:** 17%

**World Bank Global Ease of Doing business ranking 2017:** 2

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# AN INTRODUCTION TO **AEROSPACE** INDUSTRY IN SINGAPORE



“The industry is currently moving towards a SMART factory concept, adopting automation and data driven systems to stay competitive in today’s challenging environment.”

Soh Chee Siong,  
CEO, JEP Precision Engineering.





Image: SPRING Singapore

# The Singapore Aerospace Industry:

## An Evolving Landscape

By Elisa L. Iannacone and Alice Pascoletti

Singapore has grown on the back of a need for survival since its independence from Malaysia in 1965. Once a British colony, Singapore lost most of its market when it became an independent republic, yet retained the language and infrastructure from the colonials. The United States' fear of communism spreading through SEA during the Vietnam War made it eager to enter the Singapore market and Singapore found many opportunities to support the British military during this time. As the British withdrew their forces, this left the nation vulnerable so that creating its own defense capability was paramount for state security. The aircraft left behind by the Empire were models after which Singapore could build and develop a thriving aerospace industry.

With an annual output of over S\$8 billion (US\$5.6 billion), today Singapore is

positioned as a constantly evolving and leading regional hub for the aerospace industry. The Economic Development Board (EDB), the lead government agency that plans and executes economic development strategies for Singapore, has selected aerospace as one of eight target industries to develop in upcoming years given their push for developing advanced technology and manufacturing. "The EDB's aim is to continue positioning Singapore as a flagship aerospace hub within the Asia Pacific region, becoming more competitive and innovating in MRO and manufacturing," said Tan Kong Hwee, director of transport engineering, Singapore Economic Development Board.

The country now holds 10% of the global MRO market share and the government's aim is to increase Singapore's production capacity and IP by partnering with OEMs.

"The government's SPRING initiative also supports commercial companies that want to develop new capabilities. All of this combined makes Singapore an ecosystem," said Chow Kok Wah, general manager, Air Transport Training College.

Both SPRING and the EDB operate as government agencies under Singapore's Ministry of Trade and Industry. The former seeks to support SMEs in their journey to establishing themselves as strong leaders and larger businesses. "We look forward to working with partners and SMEs from the aviation industry that share the common vision to grow Singapore into a world-class aerospace hub," said John Lu, director of manufacturing & engineering, SPRING Singapore.

Though these agencies work with companies across the industrial landscape, they have supported many companies operating within the aerospace realm, particularly within the precision engineering section. Locally represented by the Singapore Precision Engineering and Technology Association (SPETA), precision engineering activities in Singapore started in the 1970s to support the manufacturing investments in the country. There are currently approximately 2,700 companies operating in the precision engineering sector, servicing a range of industries, from medical, electronics and oil and gas to aerospace. With a wide range of operations focusing on the manufacturing of jigs and fixtures, metal stamping, metal castings, precision machining, photonic and semi-conductor equipment, among several others, this industry segment plays an important role in the continued development of Singapore manufacturing capabilities.

Developing new IP products and competences through R&D and innovation is paramount for the country's continued growth and international leading position. "We want to establish more brand and technology owners in the industry. To support this, we aim to work with the industry to facilitate companies' diversification towards the aerospace sector through capability development and facilitation of partnerships," added John Lu.

Singapore has grown to host one of the largest, most diverse concentrations of aerospace companies in Asia. With 130 companies in the sector employing 20,000 employees, the country has now earned a quarter of Asia's MRO market, which

represents 90% of the country's aerospace sector. The remaining 10% is devoted to manufacturing activities. Advanced manufacturing and engineering have been identified as a key technological focus area, which is why a record of S\$19 billion (US\$13.3 billion) will be invested in the research and development of these topics over the next five years.

In an attempt to draw more investment and solidify the presence of larger players in the country, the Singapore Airshow, which inaugurated in February 2008, was created to encourage international partnerships and collaborations. According to the EDB: "In 2012, Singapore Airshow saw more than US\$31 billion worth of deals inked. The show attracted over 45,000 trade visitors from 128 countries to attend." Figures continue to rise. Industry giants have found in Singapore a place to establish their operations and build for the future. Locations such as Seletar Aerospace Park (SAP) have enabled an aerospace ecosystem to emerge.

Launched in 2007, SAP serves the aerospace sector by increasing the number of jobs in the country as well as continuously attracting leading industry players such as Rolls-Royce, Airbus Group, Bombardier and Bell Helicopter. "This is exemplified through the "Queen Bee" effect. The collocation of SMEs and MNCs in SAP creates more opportunities for networking and business collaborations, thereby enhancing competitiveness of the aerospace industry," said Leow Thiam Seng, group director of Cluster Group, JTC.

Founded in 1968, JTC is the lead government entity in charge of developing industrial infrastructure in Singapore, as well as innovative space. They have worked on projects such as Changi Business Park, CleanTech Park and the Airport Logistics Park of Singapore. "Seletar Aerospace Park (SAP) is one of JTC's iconic developments dedicated to the continued growth of Singapore as an aerospace hub. Since

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There is a clear indication that the centre of gravity for aerospace is moving from the USA towards Asia now. Singapore is an excellent place to do business and an ideal hub in terms of logistics, legal framework, safety, IP for R&D and IP protection. In terms of connectivity, one can fly all over Asia from here very easily.

”

**Ricardo Pesce, Managing Director, EMBRAER ASIA PACIFIC**





Image: Bell Helicopters

Implementing additive manufacturing for the production of parts is also an important aspect of the current R&D developments in the country. “We want to see more SMEs on-board, supporting the efforts towards the build-up of digital manufacturing in Singapore,” added John Lu. “The industry is currently moving towards a SMART factory concept, adopting automation and data driven systems to stay competitive in today’s challenging environment,” said Soh Chee Siong, CEO of JEP Precision Engineering. JEP Precision Engineering is currently adopting automation technologies for robotic loading and unloading. Hoh Chee Siong added: “Keeping up with technology is no longer a choice but our key to survival in today’s competitive market.” With a 6.1% projected annual air traffic growth for Asia Pacific, demand for skilled-labor will increase exponentially. The region will become the largest travel market in the world in the next two decades and will own well over a third of the global fleet. “Singapore will capitalize on the rapid growth in aviation activities in Asia. This country is a key global player in aerospace MRO, with an excellent seaport, airport and infrastructure,” said Lee Swee Meng, general manager of Composite Technology International (CTIPL). Singapore’s strategic geographical location is one of the reasons that have drawn many companies to base themselves in the country. Furthermore, in this 720 sq-km island, all companies can be reached easily, making it an ideal location for industry players. Singapore is renowned for its ease of doing business as well as possessing the necessary infrastructure for a successful aerospace industry. Changi Airport is widely acknowledged as a world leader amongst international airports and houses the Changi Airfreight Centre (CAC), a 24-hour Free Trade Zone (FTZ) with simplified customs for transfer and clearance of goods. The nine airfreight terminals have an annual capacity of 3 million tons per year. Initially using top-level customer service as a calling card, Singapore Airlines has now grown to establish itself as one of the leading airlines in the world, comprised of a modern 104 aircraft fleet with cutting-edge fuel efficiency. New developments for the 1,080 hectare Changi East are underway, where a third commercial runway and Terminal 5 will be

operational by the mid-2020s. The target is to double passenger handling capacity to 135 million per year. This region will be the economic center of gravity for at least the next 20 years as the potential of developing nations, such as Myanmar, Cambodia, Laos, Philippines, among others, is vast. Navigating a challenging landscape on the continent with the Himalayas and other mountain ranges, a general lack of infrastructure and safety concerns such as piracy and the South China Sea dispute, aviation is the main solution for mobility. “If we attempt to go by sea, we have the typhoon seasons and also piracy problems, which we are trying to solve[...] The only way to move the masses feasibly is by air. There is no driving or sea-route alternative,” said Liang Jerry, executive VP for Excel Aerospace. Although Singapore has found a way to position itself as the regional hub in the MRO and primarily civil aviation markets, the country has also established goals to play a niche role in the new space race. The Singapore Space and Technology As-

“ The industry is currently moving towards a SMART factory concept, adopting automation and data driven systems to stay competitive in today’s challenging environment. ”

**Soh Chee Siong, CEO, JEP Precision Engineering**

“ We want to establish more brand and technology owners in the industry. To support this, we aim to work with the industry to facilitate companies’ diversification towards the aerospace sector through capability development and facilitation of partnerships. ”

**John Lu, Director of manufacturing & engineering, SPRING Singapore**

sociation is exploring the design and construction of micro- and nano- satellites, as well as Earth-observing and telecommunications applications. With a solid remote-sensing department, Singapore will continue to develop new technologies to play a role in the sector. Certainly, with the country’s investment in smart technologies, as well as new space technologies, Singapore is positioned to maintain a leadership position within the industry for many years to come. —

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## Tan Kong Hwee

Director Transport Engineering  
SINGAPORE ECONOMIC  
DEVELOPMENT BOARD

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Technologies of interest to Singapore include predictive maintenance, Unmanned Aircraft Systems (UAS), and aircraft electrification.

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**How important is the aerospace industry for the country's global standing in the region and what are your key objectives for the aerospace industry for the next few years?**

Aerospace is a strategic sector for Singapore given our focus on advanced technology and manufacturing. The EDB's aim is to continue positioning Singapore as a flagship aerospace hub within the Asia Pacific region, becoming more competitive and innovating in MRO and manufacturing. Singapore holds 10% of the global market share in MRO. If we look at the strong growth in traffic and demand in the region in upcoming years, we are in a strong position to capture that growth in MRO and manufacturing. We need to work in collaboration with OEMs that have the technology to set up operations in our part of the world to raise our production capacity and productivity in the supply chain. We have made substantial investments in technology and innovation which are paramount to Singapore maintaining its leadership in the region.

**What are the EDB's key targets with Changi Airport T5 and Seletar Aerospace Park?**

Changi Airport T5 is part of Singapore's long-term development strategy. There are currently three terminals at Changi. With the fourth one opening in 2018, together with T5, our passenger capacity should be at 135 million/year, more than double the amount today. We aim to take advantage of the growth of commercial aviation and increasing wealth in the region to grow the aerospace industry as well.

Land has been allocated within the new airport for an industrial zone which will be launched in the mid-2020s. Until then, Singapore will continue to use Seletar Aerospace Park as the location for both runway-dependent and non-runway-dependent aerospace industrial operations. To date, 60% of Seletar's 160 hectares of industrial land have been committed. The development of the Park and the new Changi T5 underscores our strong commitment to growing the aerospace industry.

**The EDB has a strong push for implementing more robotics and automation within the industry. Could you**

**expand on this and why you believe it is important?**

The EDB works in collaboration with its sister agency, A\*STAR (Agency for Science, Technology and Research), on technology innovation. Together we coordinate the strategic technological investments Singapore must make in order to keep our lead in aerospace. We are currently looking at the application of robotics, automation, data analytics and additive manufacturing. In the nearer term, we are focused on innovations and technology that would make Singapore more competitive. This could include adapting existing technology to aerospace application. In the longer term, the vision is for Singapore to gain the capability to design and engineer new products and solutions for the market. We are encouraging our research institutions to collaborate with companies to do that. Technologies of interest to Singapore include predictive maintenance, Unmanned Aircraft Systems (UAS), and aircraft electrification.

**What is the future for UAV's in the country?**

UAVs are potentially disruptive and as a country we should try to facilitate their use as long as they are safe to residents, air traffic and property. We will certainly see more of them flying in upcoming years by many agencies, for surveillance, parcel deliveries, inspection and so on. We will learn how to deal with challenges and risks posed by flying UAVs through some test trials. Our Civil Aviation Authority of Singapore (CAAS) has signed a MoU with Airbus to experiment with delivery drones. This project is partly driven by Airbus' R&D team in Singapore. The CAAS is interested in understanding the risks posed by the use of these UAVs, the benefits they can bring and how we should adapt our regulations, which is why they are also partnering with the EDB on this process. The EDB's interest is in encouraging innovation and remaining at the forefront to capture economic opportunities that might arise from UAVs. Experimenting and understanding are the first steps towards the eventual adoption of technologies. If companies are interested in carrying out trials and development activities here, the EDB would be interested in talking to them. We will work closely with CAAS to make sure safety is not compromised.



## John Lu

Director Manufacturing & Engineering  
SPRING SINGAPORE

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Singapore has a strong existing base of companies that could develop into aerospace suppliers and product owners.

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**SPRING Singapore operates as a government arm alongside EDB to support the growth of various Singapore industries. Could you expand on SPRING's relationship with the EDB and the government?**

SPRING is responsible for helping Singapore enterprises grow and building trust in Singapore products and services. Though the EDB is the lead agency for the country's aerospace industry, SPRING works alongside them to ensure that local businesses can expand, whether they are SMEs or micro-enterprises. The organization also works alongside businesses to help them reach revenue milestones and embark on their journeys to becoming large enterprises and international players.

**What is the importance of aerospace sector for SPRING?**

Although SPRING assists businesses from different industries across the board, we maintain a strong focus on growing the aerospace sector. Most of the entities that SPRING works with and assists are precision engineering companies supporting the aerospace industry. There are currently 2,700 companies in this field. Though not all are focused on aerospace, we hope to move some into the industry as opportunities become more evident and relevant. Singapore has a strong existing base of companies which could develop into aerospace suppliers and product owners. SPRING will continue to work with the companies to capture opportunities to build up innovation and brand-ownership in SMEs. This will help them to break into foreign markets and take their operations internationally.

**Which trends and changes can we expect to see in the long term within the SME market segment in terms of digital manufacturing, Industry 4.0, and automation?**

Disruptive technologies are fundamentally modifying the global business environment and SPRING is investing heavily within the digital manufacturing and automation realm in order to prepare the market for the future. Certainly large multinationals are taking measures to become frontrunners in these areas, but we want to ensure that the gap experienced by SMEs is narrowed. SPRING has a strong role to play, not just by providing support, but by

working with partners like A\*STAR, private companies and local solution providers to create more modular solutions that are cost-effective and relevant. Modularity is paramount given the necessary transition into digital manufacturing. Operations must be interlinear so that they can link up at various stages of the production chain. SMEs that are on-board with new digital manufacturing technologies, will be well positioned to meet future customer requirements.

Technology is progressing at a rapid pace. In three to five years, cutting-edge operations today might be obsolete or modified then, even for emerging capabilities such as additive manufacturing. The new industry trends will be a bit volatile in upcoming years and we have to learn to manage it. Each enterprise will have a different risk appetite, but as a government agency, SPRING has to continue encouraging and pushing companies to be at the forefront of the race. Pushing growth is paramount for Singapore's goal of positioning itself as a regional aerospace hub. Being frontrunners means taking some risks. Investment in stages is the way forward. If SMEs wait for technology to mature, it will be too late. We must create balance between getting on-board early and taking it in stages.

**What are SPRING's key targets over the next 3-5 years for the Aerospace Industry?**

We aim to establish more brand and technology owners in the industry. To support this, we aim to work with the industry to facilitate companies' diversification towards the aerospace sector through capability development and facilitation of partnerships.

We want to see more SMEs on-board with efforts towards the build-up of digital manufacturing in Singapore. It is important to work with the industry to help SMEs become Digital Champions to take the lead in this. Working with a Singapore partner is also something we want to encourage, in order to leverage on our knowledge on the ground. Most SMEs are present in regional markets and we want them to continue excelling both locally and internationally.

We look forward to working with partners and SMEs from the aviation industry that share the common vision to grow Singapore into a world-class aerospace hub.



# Facts and Figures

## Asia's Aerospace Outlook

### Growing Economy

**66%**

of the global middle class by 2030

**4th Largest**

ASEAN's economy globally by 2050

### Growing Air Travel

**6.1%**

projected annual air traffic growth for APAC

**Largest**

travel market in the world within the next two decades

### Growing Fleet Size

**1/3**

of global aircraft deliveries over the next 2 decades

**37%**

of global fleet by 2034, nearly double that of next largest market

Source: Economic Development Board, Singapore

## Singapore's Aerospace Industry



**Total Output**  
**>S\$8B**

Amongst the largest in Asia; mix of 90% MRO & 10% manufacturing

**Total Employment**  
**20,000**

Pool of highly skilled & industry aligned talent; 80% Locals

- ✓ Maintenance, Repair and Overhaul (MRO)
- ✓ Engine MRO
- ✓ Aftermarket Services
- ✓ Manufacturing
- ✓ Research & Development

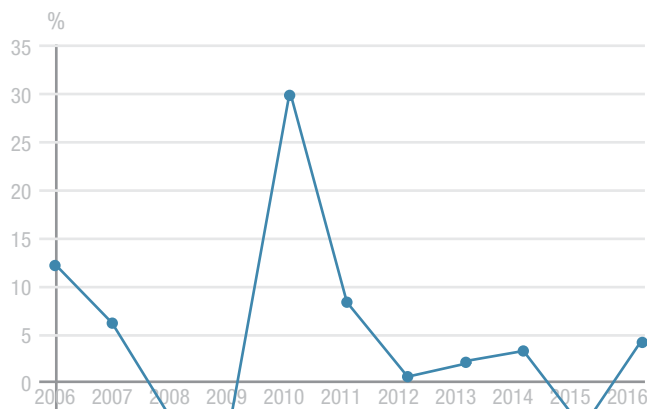
### Number of Aerospace Companies

**130**

One of the largest, most diverse concentrations of aerospace companies in Asia

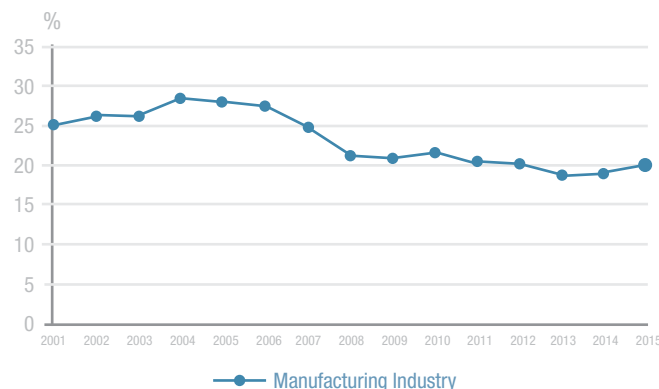
Source: Economic Development Board, Singapore

### Annual Growth in Industrial Production Index



Source: The Department of Statistics Singapore

### GDP Share of Manufacturing



Source: The Department of Statistics Singapore

# Cutting-Edge Research & Development

By Elisa L. Iannacone and Alice Pascoletti

As a part of the National Research, Innovation & Enterprise 2020 Plan, a record S\$19 billion (US\$13.4 billion) are to be invested in the Singapore Research and Development (R&D) sector over the next five years, with the aerospace industry as one of the eight key targets for funding. With a strong aim to diversify the heavily MRO-prevalent market, advanced manufacturing and engineering have been targeted as key technological fields to focus on. Tay Kok Khiang, chairman of the Agency for Science, Technology and Research (A\*STAR), Singapore's lead public agency heading R&D processes for the advancement of scientific discovery and technological innovation, said: "We collaborate with partners in both the public and private sectors and catalyze research in the industry through joint innovation."

With 5,400 staff, A\*STAR plays a strong role in advancing the country's workforce through a series of scholarships and talent development programs. The entity also runs a Research Consortium for Aerospace-focused R&D, which includes 15 lead commercial aircraft and engine manufacturers, specialized aviation materials companies and enterprises such as Airbus, Boeing, Safran, Bombardier, GE, Pratt & Whitney, Rolls-Royce, Honeywell, SIA Engineering and ST Aerospace. "Launched in 2007, the consortium undertakes pre-competitive research to address challenges in the Aerospace Industry," added Tay Kok Khiang.

The consortium has carried out over 100 projects to date. A\*STAR's private-public Advanced Remanufacturing & Technology Centre (ARTC) focuses on R&D for surface enhancement, repair and restoration and product verification. The goal is to develop processes that can be immediately adopted by the industry at large. Finding a second life for products that have reached their natural end-of-life is a strategy being developed by many companies within the

aerospace industry. On a larger scale, ST Aerospace has acquired leasing aircraft, which can then be converted from passenger to freighter, and ultimately used for parts at the end of their life-cycle.

Rapid changes in the aerospace landscape are forcing companies to innovate and create alternate sources of revenue. With new generation air fleets entering the market, the need for MRO services will diminish in frequency. "The trend of the MRO is going to be driven by the increase in the new generation aircraft, which will double every three years. The impact will be strongly felt given that maintenance needs have diminished significantly for these aircraft. The 787 needs maintenance every 12 years, whereas older models needed it every six years," said Lim Serh Ghee, president, ST Aerospace.

Rolls-Royce has collaborated with Nanyang Technological University (NTU) by making a S\$75 million (US\$53 million) investment for continued R&D at the Rolls-Royce@NTU Corporate Lab. "It is a major long-term partnership where we have set up three large research centres over a five year plan [...]. We are focusing on manufacturing and re-manufacturing instead of throwing away used aircraft parts, to save costs and improve manufac-

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A\*STAR is globally unique given that it operates like a government funded University. They have capabilities in almost every industrial sector, invest heavily in R&D, and develop collaborations with international companies. They leverage their technical infrastructure and couple it with world class R&D capabilities, and bring together leading industry players in collaborative initiatives.

”

turing processes," said Prof. Louis Phee, chair, School of Mechanical & Aerospace Engineering, NTU.

The research hub combines NTU's leading infrastructure, cutting-edge engineering and science research, and internationally recognized faculty with Rolls-Royce's industrial capabilities, leading engineering services and international reach. The British aircraft engine manufacturer is also exploring power and control technologies with NTU's School of Electrical and Electronic Engineering, and software development with the School of Computer Science and Engineering. "Rolls-Royce invested £1.2 billion (US\$1.5 billion) on R&D in 2015, and has established a network of 31 University Technology Centres worldwide," said Bicky Bhangu, director Singapore, Rolls-Royce.

NTU also has a S\$5 million (US\$3.5 million) partnership with Leonardo for helicopter aerodynamics. "These major international players see great potential in Singapore and know that our infrastructure is cutting-edge. I would like investors to recognize this great potential," added Prof. Louis Phee.

With 30 researchers, the NTU Satellite Research Center, which sits under the School of Electrical and Electronic Engineering, is also pushing Singapore's space R&D to the forefront. NTU's focus on communication payload started years ago alongside the University of Surrey. After building the XSAT, their first satellite, Singapore Technologies Satellite Systems was created as the country's first commercial satellite company. NTU currently holds and monitors seven satellites in space.

Singapore is highly interested in the development of small satellites to position



**Tom Gentile, CEO, SPIRIT AEROSYSTEMS**



itself as an expert in niche space technologies. Though the young space industry in the country does not have the capacity to become a leader in all-things space, it has the cutting-edge technology capabilities and necessary infrastructure to position itself as a highly specialized leader within the space market. Thales in Singapore has established a Space Centre of Excellence for Research and Technology (R&T) and has partnered with NTU to create S4TIN (Smart Small Satellite Systems), a joint lab for the development of nano-satellites that leverages on CINTRA, another joint lab between NTU, Thales and CNRS. Their focus is on nano-electronics and nano-photonics. “We are always on the lookout to develop collaborations with other research institutions and organizations,” said Dr. Erick Lansard, vice-president for Technical and Space Development, Thales. Thales in Singapore has also established the first regional Thales Innovation Hub in the country to create innovative disruptive solutions. “The target is not only to fly prototypes, but also to develop new industrial systems that could be manufactured locally in partnership with local actors, and new applications and services,” added Dr. Lansard.

“

Whereas regulation was initially a driving force behind the industry, we are now facing a situation where rules or regulatory frameworks have to catch up with technology. This will continue to be the trend in the future. The fundamental driver for these technologies to be developed is cost. Roughly, half of the investment budget in our industry goes into reducing cost. VR can, for example, assist by omitting physical presence, whether it means maintenance training or airport familiarization, and so help reducing classroom, travel and other costs.

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**Tom Vandendael, Senior VP, Regional Management, LUFTHANSA SYSTEMS**

Industry leaders have taken an active role in the development of R&D programs to ensure Singapore can maintain its leading position as an R&D hub in the region. SIA Engineering, ST Aerospace, and DSO National Laboratories joined forces with the Department of Mechanical Engineering at the National University of Singapore (NUS) to launch the Centre for Aerospace Engineering (CAE) in 2013. With aerospace-focused research, education and outreach activities, CAE provides innovative solutions for the industry. Their research projects range from the study of surface manipulation for drag reduction and composite damage and repair, to the

development of a heavy fuel diesel engine for Unmanned Aerial Vehicles (UAVs). The Singapore government’s push to develop new technologies, national IP and innovations for the aerospace industry is paving the way for a bright and successful future for the country. Singapore plays host to the headquarters and R&D functions of many lead international industry players. This is positioning the country as an aerospace R&D hub. With the increase in manufacturing and space activities in the country, as well as the aim to maintain a leadership position in the aerospace industry, the R&D sector will only continue to grow. —

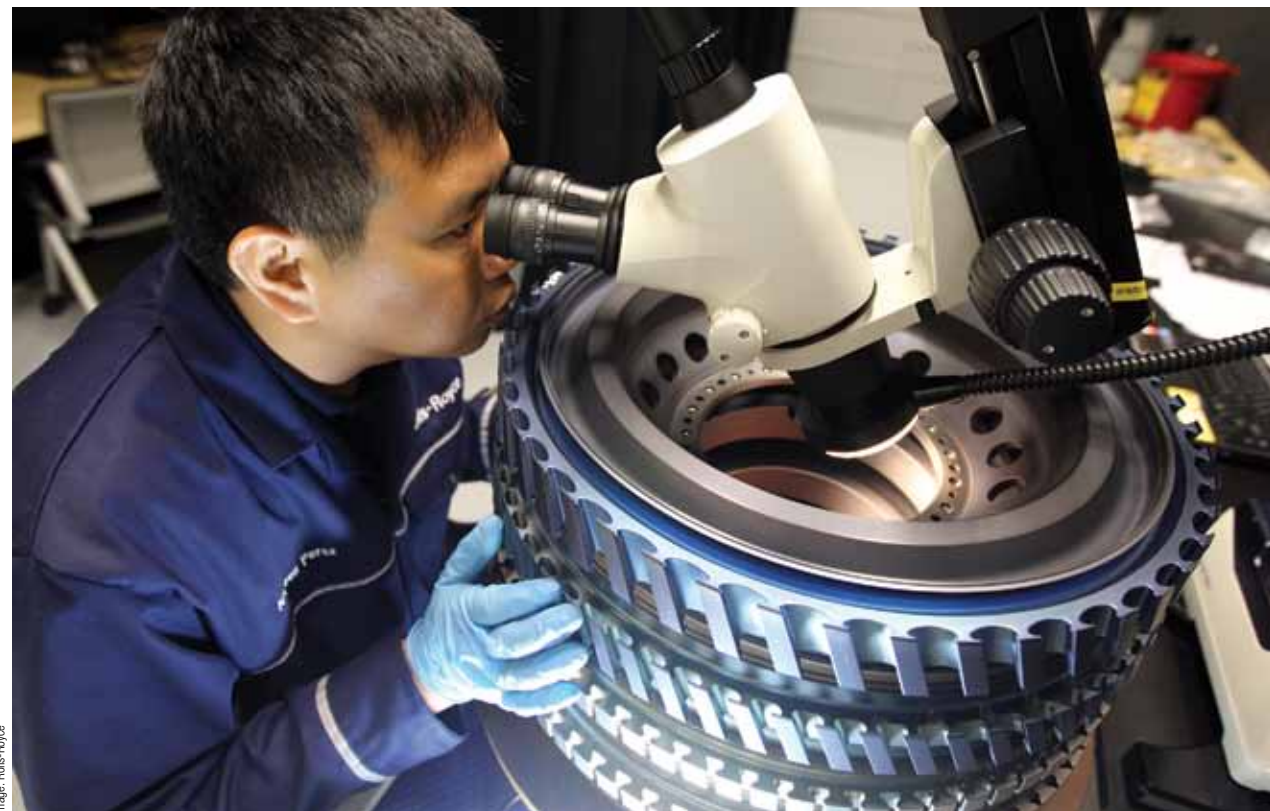


Image: Rolls-Royce

## Tay Kok Khiang

Chairman

**A\*STAR AEROSPACE PROGRAMME  
AGENCY FOR SCIENCE,  
TECHNOLOGY AND RESEARCH**



“

A\*STAR Aerospace Research Consortium was launched in 2007, and undertakes pre-competitive research to address challenges in the aerospace industry. Through this platform, members can leverage on A\*STAR’s research resources and state-of-the-art infrastructure.

”

### Could you describe A\*STAR’s core focus and operations in Singapore?

The Agency for Science, Technology and Research (A\*STAR) is Singapore’s lead public agency that spearheads economic-oriented research to advance scientific discovery and develop innovative technology. With 5,400 staff, research is largely organized under two entities: the Science and Engineering Research Council and the Biomedical Research Council. The research entities are primarily located in Fusionopolis and Biopolis respectively. We collaborate with partners in both the public and private sectors and catalyze research in the industry through joint innovation. The science and engineering research entities conduct research within clusters such as Electronics, Chemicals, Marine and Offshore, MedTech, Biologics and Aerospace. Our research focuses on creating economic growth and jobs, and enhancing lives. We work closely with the Economic Development Board of Singapore to support the industry in Singapore and collaborate with global partners. A\*STAR plays a key role in nurturing and developing a robust and diverse innovation workforce for Singapore’s research, innovation and enterprise ecosystem through our scholarship and talent development programs.

### What is the importance of the aerospace sector for A\*STAR and what is the vision for the sector moving forward?

The aerospace sector is an important sector for Singapore which has seen a steady growth of 8.6% CAGR over the last 20 years and employs some 20,000 staff, 90% of which are skilled jobs. A\*STAR collaborates with the aviation industry through its

Aerospace Program, and the flagship for this effort is the A\*STAR Aerospace Research Consortium. Launched in 2007, the Consortium undertakes pre-competitive research to address challenges in the aerospace industry. Through this platform, members can leverage on A\*STAR’s research resources and state-of-the-art infrastructure. The consortium engages in all aspects of aerospace R&D from advanced materials, manufacturing processes and automation, information and communication, inspection and non-destructive testing, computational modeling and dynamics. Starting with just four founding members, the consortium now has 15 members, which includes many of the leading commercial aircraft and engine manufacturers, component and specialized aviation materials companies, and leading local enterprises. To-date, the A\*STAR Aerospace Program has undertaken more than 100 multi-disciplinary projects.

### Could you outline some of the projects that have been undertaken by A\*Star?

Some of the projects include research into new materials, ranging from the treatment of pipelines to prevent coking, to new materials with special properties useful for aviation. This includes conductive composites, which may one day replace the current approach of protecting composite structures of the latest generation aircraft against lightning strikes.

In electronics, we are innovating designs for harsh environments, such as high-temperature packaging, in order to meet the future needs of “more-electric aircraft”, for which current designs are inadequate. Smart sensors that enable continuous and on-line monitoring of engine oil levels, an

improvement on the current off-line periodic checks, is another example. In coatings, we research super-hydrophobic materials as well as ice-phobic coatings. There is an interest in Direct-Write technologies, which will allow for efficient and cost-effective health monitoring of modern aircraft. We undertake research to improve internet connectivity and capacity to meet the needs of modern society.

### What are your views on the regulatory framework which supports the aerospace industry?

The aerospace industry, from an engineering and MRO perspective, is highly regulated and international in nature. Although there are country to country nuances, most of the Western World practices are regulated under the Federal Aviation Administration (FAA) and the European Aviation Space Agency (EASA), and the two are largely similar in requirements.

Work done in Singapore has to meet the requirements of the Civil Aviation Authorities of Singapore (CAAS) and, depending on the market where the work is intended for, it usually has to meet the FAA’s or the EASA’s requirements as well as the country requirements of the end-user. These requirements relate more to engineering developments and MRO. Certification would be done at the product development stage. To facilitate recognition of work done in Singapore, for example, the CAAS has a Bilateral Aviation Safety Agreement (BASA) with the FAA which outlines a mutual acceptance of design and production certifications. Companies which have work certified through the CAAS might benefit from this cross-recognition.





## SIA Kheng Yok

Chief Executive  
**ASSOCIATION OF AEROSPACE INDUSTRIES (SINGAPORE)**

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Singapore's aerospace industry structure is quite unique, with the heaviest concentration of MRO activities in Asia-Pacific. The Singapore Economic Development Board (EDB) reports that MRO comprises 90% of the industry output.

”

### Could you outline the main objectives of the association?

The Association of Aerospace Industries is 13 years old and we have about 130 members. Our membership comprises OEMs, MROs, small and medium-sized enterprises and a full range of service providers. It is a reflection of the composition of the aerospace industry in Singapore. Our mission is to promote Singapore as a leading aerospace hub, for the benefit of all our members and their business competitiveness.

What we do can be summarized in three points: Firstly, we serve as the voice of industry and play a role in policy advocacy. We also work with the government on directions for the future development of the industry we represent. The second point is about developing the aerospace community, because we believe there are many opportunities to collaborate and draw synergies from one another. Thirdly, we facilitate businesses through organizing overseas missions, exhibitions and helping with market connections.

### What kinds of members does the Association look for and how can they join?

We welcome members who can contribute as well as benefit from being a part of the AAIS community. The core membership remains anchored by aerospace OEMs, MRO and suppliers. But we are also open to members who provide services to the industry. More recently, this also includes companies with expertise in applying technology to aerospace – in fields such as data analytics, digitization, robotics and Industry 4.0.

### Which are the current trends you have observed in the Singapore Aerospace market and which segments do you anticipate to experience strong growth?

Singapore's aerospace industry structure is quite unique, with the heaviest concentration of MRO activities in Asia-Pacific. The Singapore Economic Development Board (EDB) reports that MRO comprises 90% of the industry output. This has arisen from Singapore's traditional role as an air transport hub giving rise to two major domestic MRO players - ST Aerospace, with roots in the defense sector, and SIA Engineering Company (part of the Singapore Airlines group). ST Aerospace is now ranked one of the world's largest third party MROs and SIA Engineering Company has an extensive network of 26 joint ventures. The

world's major OEMs have also chosen to make Singapore their significant base for addressing the Asian market.

A growing sector is advanced manufacturing. Rolls-Royce assembles and tests Trent engines in Singapore. Both Rolls-Royce and Pratt and Whitney also manufacture fan blades here. The supply chain around these activities is creating a positive spin-off locally, as well as, to other countries in our neighborhood.

### What is the advantage of operating in Singapore as opposed to other markets in the Asia-Pacific Region?

The strong advantages for Singapore have been our trusted brand, open economy, location, connectivity, industrial base, comprehensive aerospace cluster and skilled talent. Our government invests very heavily in education and research and development, in support of industry. We also have a very strong OEM presence that differentiates us from others. The EDB estimates we command a quarter of the regional MRO market. Our hope would be to continue to grow and extend our market reach.

### Singapore's manpower can often be a challenge to operations given the incredible demand and constant turn-over of employees. How does the country aim to navigate this roadblock?

In terms of growing the country's skill-base and manpower, there is a very strong spirit of cooperation between government, employers and unions. This tripartite relationship is the cornerstone of decades of harmonious industrial relations in Singapore. The industry and the educational institutions also work very closely together to ensure we develop industry-ready graduates. This has resulted in a very responsive and far-sighted education system that anchors our competitiveness as a country. Education and training opportunities do not just stop upon graduation from school. There is a now a framework and system that enables everyone to be re-skilled and upgraded throughout his/her working life, in order to adapt to changes in the workplace. It is not correct to say that there is a constant turn-over of employees. The aerospace industry in particular, is known for its ability to retain its employees and provide good career opportunities. In fact it is the sector with one of the highest percentages of local employees – around 80%.

## Educational Institutions

By Elisa L. Iannacone and Alice Pascoletti

With a projected growth of three times the current air fleet by 2031, countries across Asia are racing to establish strong educational institutions to fill the projected gap in the relevant skills. With over 1,700 aerospace graduates per year, the Singapore government is investing heavily in developing the professionals of the future, and has a strong relationship with the aerospace industry and country's educational institutions. “This tripartite relationship is the cornerstone of decades of harmonious industrial relations in Singapore,” said SIA Kheng Yok, chief executive, Association of Aerospace Industries, Singapore.

Singapore has world-class universities, such as Nanyang Technological University (NTU) and the National University of Singapore (NUS), as well as various polytechnics that are investing in strengthening their facilities. The Singapore Polytechnic has a four-story Aero Hub that houses an aircraft hangar with a Hawker HS125-700A, King Air B90, A4SU Super Skyhawk and a Bell UH-1H Helicopter. They have also created laboratories and an R&D center to assist the students receiving a diploma in Aeronautical Engineering (DARE) and a diploma in Aerospace Electronics (DASE). The R&D Center has a flight simulator that can recreate an F16 cockpit, Boeing 737 cockpit and F1 race-car cockpit. It also has an Airbus 320 flight simulator and maintenance trainer. They are also focused on the development of vertical take-off and landing (VTOL) vehicles, intermeshing and co-axial Unmanned Aerial Vehicles (UAVs) and hybrid rocket propulsion systems.

Temasek Polytechnic invested S\$30 million (US\$21 million) to create the 6,000 sqm Temasek Aviation Academy (TAA), as an addition to the School of Engineering, making it the largest dedicated aviation training facility in the country. The TAA has an aircraft hangar with a Hawker Siddeley 700A private jet, a closed-loop wind tunnel and a VR studio. The polytechnic also acquired full-flight simulators and the latest training equipment avail-

able. With over 40 years operating in the country, the Singapore Institute of Aerospace Engineers also decided to found a training school for the industry in 1999, which is how the Air Transport Training College (ATTC) emerged. The ATTC has established a training complex at Seletar Aerospace Park with a full hangar that has access to the Seletar Airport runway. “In these 17 years we have trained more than 40 MBA students, over 300 bachelor degree students, 300 diploma students and over 4,000 certificate students,” said Chow Kok Wah, general manager, ATTC.

The School of Mechanical and Aerospace Engineering (MAE) at NTU offers two

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We believe that getting involved with partnerships with universities and research institutions will help nurture talent and inspire the next generation of future engineers and scientists. This strong link with the local institutions will help potential engineers understand how their academic excellence can be applied in the workplace. We take around 100 interns every year into our Singapore workforce.

”

**Bicky Bhangu, Director, SINGAPORE ROLLS-ROYCE**

“

I have concerns about the airline industry in SEA going too fast. The training of pilots and aircraft maintenance cannot keep up given that the business has grown too fast.[...]Singapore is well placed to provide the training facilities required to meet this demand for engineers and technicians. But the region is still falling short experiencing fast growth with insufficient technical education infrastructure to support it.

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**Lim Yeow Khee, President, SINGAPORE INSTITUTE OF AEROSPACE ENGINEERS**

“

The main roadblock to the private aviation's operations is the huge lack of information sharing within the industry segment. WOA provides a platform where pilots, operators and owners can collaborate and share information about crossing borders or receiving support.

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**Yeow Meng, Managing Director, WINGSOVERASIA**



# Locations of Educational Institutions



Over **1,700**

Aerospace-trained graduates annually

Close collaboration with industry to deliver industry-relevant training and education

US\$ **13.4 Billion**

to be spent on R&D over the next 5 years

Investments by Institutes of Higher Learning

**Singapore Polytechnic**

Opening of four-story AeroHub (Q1 2016)

**Temasek Polytechnic**

Opening of S\$30m Aviation Academy to train students and working adults

- 1 National University of Singapore
- 2 Nanyang Technological University
- 3 Singapore Polytechnic
- 4 Temasek Polytechnic
- 5 Nanyang Polytechnic
- 6 Republic Polytechnic
- 7 Ngee Ann Polytechnic
- 8 Singapore Institute of Technology
- 9 Singapore University of Technology and Design



## Prof. Louis Phee

Chair  
**SCHOOL OF MECHANICAL & AEROSPACE ENGINEERING, NANYANG TECHNOLOGICAL UNIVERSITY**

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The Singapore industry is gradually shifting from being primarily focused on MRO to becoming a world leader in cutting-edge technologies and innovations.

”

### Could you outline the School of Mechanical and Aerospace Engineering's core mission and future outlook?

The School of Mechanical and Aerospace Engineering (MAE) at Nanyang Technological University is a recognized international leader. We offer two Bachelor degree programs in Mechanical and Aerospace Engineering and various MAE graduate programs. The aerospace program that we run at NTU started 12 years ago. It was the only aerospace engineering course in Singapore for many years. We are also proud to say that the number of students we are teaching is steadily increasing. We started with about fifty students per year and have now reached one hundred and thirty per year. Our goal is to equip the leaders of tomorrow with all the necessary skills and tools they need in order to continue developing the Singapore and regional aerospace industry. We strive to continuously innovate and grow our academic excellence through many R&D projects as well as international collaborations.

MAE houses the Air Traffic Management Research Institute, which is jointly set up together with the Civil Aviation Authority of Singapore, with the aim of turning Singapore into a strong hub for Air Traffic Management. Among the R&D projects the school is exploring, there is the future of airport terminals at Changi as well as looking into the air traffic management for drones.

### What kinds of new developments is Singapore looking to implement within the UAV realm?

Both UAVs and autonomous cars are imminent. For Singapore, however, implementing aerial deliveries is a big challenge. There are many obstacles to overcome and a manpower shortage that has to be addressed, so one viable way to achieve this would through the use of drones coupled with autonomous vehicles. We are still at the R&D stages, but the universities and research centers are all looking into the direction of autonomous intelligent vehicles. All these novel ideas are now being explored at NTU.

### Singapore's aerospace industry is composed of a 90% MRO presence. Could you describe the trends you notice for the industry moving forward?

The Singapore industry is gradually shifting from being primarily focused on MRO to becoming a world leader in cutting-edge technologies and innovations. This trend is going to take some time and will require a lot of perseverance on part of the industry and the government. NTU is doing its part by training the best people who can rise to the challenge. Agencies like the Singapore Economic Development Board are bringing in all the large industry players, such as Rolls-Royce and Pratt & Whitney. It is amply clear that these multinationals are here for the long run. It is no secret that presently we are in a bit of a slump, but we know the industry will pick up again. Aircraft sales have increased in recent years. Though they will not require much maintenance to begin with, they inevitably will in the long term, and when they do, Singapore will be ready to serve them.

### Could you describe some of the universities national and international collaborations?

The collaboration that we have with Rolls-Royce for continued R&D is very significant to NTU. It is a major long-term partnership where we have set up three large research centers over a five year plan. The first investment involved S\$75 million. We are focusing on manufacturing and re-manufacturing instead of throwing away used aircraft parts to save costs and improve manufacturing processes. Rolls-Royce is also collaborating with NTU's School of Electrical and Electronic Engineering to explore power and control technologies, and the School of Computer Science and Engineering for software development. Moving forward, we will be looking into other areas.

We also have a collaboration with Leonardo, a global high-tech company for aerospace, defense and security, where we have an on-going S\$5 million partnership on aerodynamics for helicopters. These major international players see great potential in Singapore and know that our infrastructure is cutting-edge. I would like investors to recognize this great potential. Singapore and NTU are already researching and designing satellites, leading the way in terms of innovation and R&D. Thus Singapore is a place where companies can plan for the long-term and know they have a reliable partner to support them.



# AVIATION



"The GDP growth in Asia Pacific is the most pronounced anywhere in the world. It is our objective to harness this growth into a sustainable future for our customers. Growth is certainly part of our plan and this facility in Singapore was designed for scalability."

Sameer A. Rehman, Managing Director Asia Pacific, Bell Helicopter Asia



# Pushing Singapore's Competences forward through Regional Competition

By *Elisa L. Iannacone and Alice Pascoletti*

According to Boeing's Current Market Outlook, 3,860 new airplanes, valued at US\$565 billion, will be required in Southeast Asia in the next 20 years, along with a need for nearly 250,000 commercial airline pilots and just under 270,000 technicians. "China will lead the region with a demand for 111,000 pilots and 119,000 technicians, followed by Southeast Asia with 62,000 pilots and 67,000 technicians," said Ralph L. (Skip) Boyce, president Boeing Southeast Asia.

Emerging markets, such as Indonesia, have been the ideal launching pad for Low Cost Carriers (LCCs), such as LION Group, to flourish. "The most extreme growth we have detected stems from the Indonesian market, with over 400 aircraft on order and the manpower requirements that go along with those," said Tom Dowdall, chief executive officer, Aviation Labour Group. Despite slowing down, Air Asia also continues growing in the region. "According to the annual report, more than 75% of the airplanes needed will be for single-aisle airplanes, as we continue to see a rise in the number of low-cost carriers as well as strong annual traffic, with growth rates of 6.4% for Southeast Asia," added Ralph L. (Skip) Boyce.

Although the rate at which LCCs has grown over the past 15 years has decreased, there is still high-expectation for increased demand. However, given the rising competition in the region, many LCCs are focused on merely trying to cover their operational costs. "The rate of LCC growth in Southeast Asia has slowed over the last couple of years but the overall market continues to expand and there are opportunities for fur-

ther growth given the anticipated economic middle class growth," said Brendan Sobie, chief representative Southeast Asia and chief analyst, CAPA – Centre for Aviation. Despite an on-going growing demand, the South East Asia (SEA) markets have expanded so ambitiously that overcapacity is starting to become a real issue. Airlines from SEA, North Asia and the Gulf states have created an environment of increased competition, creating an imbalance between demand and capacity, lowering their profit margins. "The profit margin for airlines in SEA in 2016 were below the industry average and the Asia Pacific average. Profits are likely to fall in 2017 due to overcapacity, which is pressuring yields, and rising fuel prices," added Sobie. This challenging environment could persist well into 2018 given the low-cost business model that is offering passengers the opportunity to fly with smaller operators in emerging markets and are increasing their number of long-haul flights.

Although the severe overcapacity obstacles faced in 2014 were seemingly overcome in the last two years, the outlook for 2017 is one of further challenges. Singapore Airline's December 2016 operating results showcase that although the Passenger Load Factor (PLF) was higher for East Asia given the holiday season demands, the PLF for the South West Pacific declined as capacity growth outstripped demand. "The huge order book, which consists mainly of orders from LCC groups, indicates the current overcapacity situation is not about to go away anytime soon," added Sobie. Asia's economic growth has surpassed the global rate by 2.9%, with an annual

pace of 4.1%, with China and India as the main drivers for the continent. Currently holding a 31% share of the world's GDP, Asia is projected to grow to carry a 39% of global GDP by 2035, due to the rapid growth experienced in emerging markets and growing middle class in the region. Growing alongside the wealth contained within the continent, the business aircraft industry segment has experienced a steady rise over the last 10 years. A prime example is Bombardier, with its Learjet, Challenger and Global business jets, and plans to remain as the leader in this class of mobility for the SEA region. Its goals are tied to the Global 7000 business jet's entry-into-service in the second half of 2018. "This will bring a class-defining product to market that will capture much of the projected growth within business aviation," said Simon Wayne, general manager, Singapore Service Center, Bombardier Aerospace Services Singapore. The Global 7000 will fly across the globe and can at times reach a speed of up to M 0.925.

Bell Helicopter is currently developing the first commercially certified fly-by-wire helicopter, the Bell 525 Relentless. With a capacity of up to 20 passengers and two pilots, the electronics and actuators controlled helicopter aims to "take the world by storm," according to Sameer A. Rehman, managing director, Bell Helicopter. Despite the global downturn of oil prices, helicopter OEMs in the region have maintained steady operations. "Composite Technology International (CTIPL) did factor in oil prices into the annual projection, but we discovered that the demand did not diminish. Companies such as Airbus Helicopters, Leonardo Helicopters and Bell Helicopter have described steady helicopter sales in the region," said Lee Swee Meng, general manager, CTIPL.

With the capacity to repair helicopter rotor-blade repairs, CTIPL is looking to continue growing its international client base. With many Singapore-based companies looking to strengthen their ties to the Asia-Pacific region, the government has strategized to be prepared for the increased demand. SAP continues attracting industry leaders and Changi Airport is prepared to capture the projected aviation growth in the region. The Changi Airport expansion includes a third commercial runway and a new terminal. Optimizing the current airport infrastructure is on-going in

the country, which also marks a strong difference from Hong Kong, also considered to be an aerospace hub in the continent. Though both abide to a comparable regulatory environment, Hong Kong's airport is already congested, particularly for business aviation. "When the planning of that airport was done, they catered for what they believed would be the largest private-jet market possible, about 30 aircraft, whereas there are well over 100 aircraft parked at the airport," said John Riggir, vice president and general manager, JET Aviation. Despite the inevitable competition amongst the two hubs, many believe that it is through joint efforts that the best results are attained. "Surely, when it comes to airlines passenger yield, there is clear competition as there is also competition from the Middle East, but I do not see Singapore as a country afraid of China. Historically these regions join hands, rather than just have straightforward competition," said Tom Vandendael, senior VP, Lufthansa Systems. Leading the way in airspace surveillance given its geographical location, Singapore has emerged and grown through both international and national collaborations. This attitude is a part of Singapore's intercultural fabric, and the country will continue to build strong ties within the region. The Asian market is strongly OEM oriented and Singapore is identified as a solid launching pad into the region. The speed at which many companies have been able to grow has a lot to do with Singapore's ease of doing business environment, governmental support and professional know-how in the industry. "Singapore has strong know-how as a country. We would have never been able to develop a company this fast in another country in Asia. The infrastructure makes it easy, but so does the engineering and technical capacity," said Thibaut Champion, chief operating officer (Production), Sabena Technics. With over 20 years in the country, and based in Hong Kong since 2008, JET Aviation has been growing steadily since China started purchasing large jets. The company has decided to make Singapore the center of its operations. "JET Aviation built a new facility in 2014, which was added to our old hangar, and we are building a new hangar in Singapore now. Overall, we will grow to occupy a space of about 15 thousand sq m, which will make Singapore our hub for Asia-Pacific," said John Riggir.

Singapore has also positioned itself as a strong aircraft leasing and financing hub in the region. The government has developed attractive tax structures and incentives for the sector, which was virtually non-existent a mere 15 years ago. "In this short time, Singapore has become the Ireland of Asia in terms of aircraft leasing," said Brendan Sobie.

Back in 2006, BOC Aviation, previously the Singapore Aircraft Leasing Enterprise, was the only leasing company operating in the country. It has since been purchased by the Bank of China and held a successful IPO. Global leasing companies that would generally base their offices out of Europe or North America, are now shifting or expanding their operations into Singapore given the level of support they receive from the country.

Banking structures for aircraft financing are another indispensable factor for attracting industry players into the country. Several banks have developed financing departments that support the airlines and leasing companies in Singapore. Many law firms have also moved into the country to become a part of the growing leasing sector. "FTS' main target customers are aircraft leasing companies, given that most airlines lease nowadays. All of the main aircraft leasing players are based here, which makes our operations much easier and our customer-base easily reachable," said Darrel Chua, general manager, Flightech Systems (FTS), a company that provides wireless entertainment and connec-

tivity solutions and products for industrial networking.

Singapore's ease of operations' benefits extends across the value chain, impacting even in-flight entertainment solutions providers. The General Administration of Press and Publication (GAPP), previously known as the Ministry of Culture, acts as a film board censor that requires all films to be played in-flight to be transcribed in full six weeks prior to being approved. Singapore Airlines uses unedited cuts, but certain airlines, such as Malaysian Airlines and most Middle-Eastern carriers, require the films to be re-edited. "In China we need to be sensitive to both the political and cultural restrictions that may apply. Our strongest challenge at the moment is digital communication with our Beijing office because of the 'great firewall' of China," said Pravin Jumabhoy, executive director, Images in Motion.

Across the industry spectrum, from MROs, manufacturers and OEMs to service providers, the general sentiment is one of trust in the Singapore aerospace industry, as well as in the government entities in charge of fuelling the small island's growth. Leading OEMs and suppliers that carry out manufacturing activities in the country are being encouraged to grow and continue developing their operations. Currently producing engine casings, gears, bleed valves, and fan blades, as well as avionics computers, among others, Singapore is well placed to continue expanding its operations outside of the MRO realm. —

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Singapore has strong knowhow as a country. We would have never been able to develop a company this fast in another country in Asia. The infrastructure makes it easy, but so does the engineering and technical capacity.

**Thibaut Champion, Chief operating officer (Production), Sabena Technics**”

“

The Southeast Asia airline sector needs consolidation but is not about to get it. While the fundamentals of the market are attractive – including rapid economic and middle class growth – the level of competition is at times extreme and capacity levels irrational.

**Brendan Sobie, Chief Representative Southeast Asia and Chief Analyst, CAPA – CENTRE FOR AVIATION**”

# Seletar Aerospace Park

Phasing Plan as at Jan 2016



|   |    |    |   |   |
|---|----|----|---|---|
| 1 | 8  | 15 | <b>READY-BUILT FACILITIES</b><br>21 JTC Aviation One<br>22 JTC Aviation Two<br>23 JTC aeroSpace | a |
| 2 | 9  | 16 |   | b |
| 3 | 10 | 17 |   | c |
| 4 | 11 | 18 |   | d |
| 5 | 12 | 19 |   | e |
| 6 | 13 | 20 |   | f |
| 7 | 14 |    | g   |   |

# Singapore Aerohub in figures

Changi Airport Traffic

|                                   | Latest Period | Latest Data | % Change (Y-o-Y) | Previous Period Data | % Change (Y-o-Y) |
|-----------------------------------|---------------|-------------|------------------|----------------------|------------------|
| <b>Air Cargo Handled (Tonnes)</b> | 2016          | 1,969,434   | 6.3              | 1,853,087            | 0.5              |
| <b>Aircraft Landings (Number)</b> | 2016          | 180,251     | 4.1              | 173,152              | 1.4              |

Civil Aircraft Arrivals, Departures, Passengers and Mail, Changi Airport, Annual

|                             | 1976      | 1986      | 1996       | 2006       | 2009       | 2012       | 2015       | 2016       |
|-----------------------------|-----------|-----------|------------|------------|------------|------------|------------|------------|
| <b>Aircraft Arrivals</b>    | 32,710    | 36,514    | 83,345     | 107,092    | 120,184    | 162,349    | 173,152    | 180,251    |
| <b>Aircraft Departures</b>  | na        | na        | 83,404     | 107,132    | 120,176    | 162,373    | 173,182    | 180,239    |
| <b>Passenger Arrivals</b>   | 1,859,505 | 4,445,576 | 11,587,394 | 16,677,822 | 18,026,026 | 25,055,954 | 27,491,096 | 29,203,726 |
| <b>Passenger Departures</b> | 1,880,888 | 4,489,692 | 11,542,408 | 16,690,277 | 18,062,970 | 24,853,645 | 27,344,459 | 28,953,978 |
| <b>Passenger Transit</b>    | 795,465   | 1,132,451 | 1,384,446  | 1,664,984  | 1,114,982  | 1,272,205  | 613,409    | 540,335    |

Source: Civil Aviation Authority of Singapore

Air Cargo Discharged by Region/Country of Origin, Annual

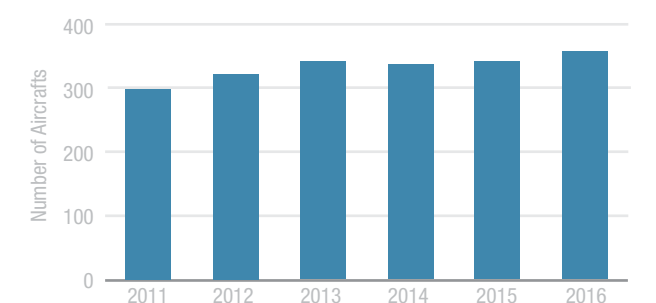
|                        | 2016      |
|------------------------|-----------|
| <b>Total</b>           | 1,083,999 |
| <b>South East Asia</b> | 163,745   |
| <b>Indonesia</b>       | 55,215    |
| <b>Malaysia</b>        | 17,401    |
| <b>Philippines</b>     | 11,401    |
| <b>Thailand</b>        | 53,440    |
| <b>Vietnam</b>         | 20,292    |
| <b>North East Asia</b> | 486,635   |
| <b>China</b>           | 152,348   |
| <b>Hong Kong</b>       | 140,873   |
| <b>Japan</b>           | 85,340    |
| <b>South Asia</b>      | 71,894    |
| <b>Middle East</b>     | 39,980    |
| <b>Oceania</b>         | 133,401   |
| <b>Europe</b>          | 163,696   |
| <b>France</b>          | 8,113     |
| <b>Germany</b>         | 15,680    |
| <b>United Kingdom</b>  | 22,757    |
| <b>North America</b>   | 19,010    |
| <b>Other Regions</b>   | 3,059     |
| <b>Not Stated</b>      | 2,579     |

Source: Civil Aviation Authority of Singapore

More than **100** airlines  
 flying to some **380** cities  
 in about **90** countries  
 and territories worldwide.

Each week, about **7,000** flights  
 land or depart from Changi,  
 with more than **58.7 million**  
 passengers passing through the airport a year.

Commercial Aircraft Movements at Changi Airport



Source: Changi Airport Group





**Could you provide a brief history of ATR internationally and describe the importance of establishing your operations in Singapore?**

**Christophe Potocki:** ATR was created in 1981 in Toulouse, France, as a joint venture between Airbus and Leonardo. Over the last 35 years, we have delivered more than 1,358 aircraft to nearly 200 customers in about 100 countries. In many regions – and Asia is a perfect example – turboprops are the only possible solution to travel from one point to another. Regional aircraft must have the capability to operate in any severe or restricted environment, such as on short and/or narrow runways, at high altitude airports, on semi-prepared airfields, in extreme temperatures etc. This is a huge market worldwide: regional aviation represents 25% of the fleet.

**Jean-Pierre Clercin:** Just as we do all over the world, ATR's mission in Asia is to connect communities and help their sustainable growth with our turboprop aircraft. Asia is the fastest growing aviation market and ATR is fortunate to enjoy great continuing

success in the region. Today, ATR counts a fleet of 377 aircraft in Asia Pacific, operated by more than 50 customers and operators in 22 countries. It is essential to us to demonstrate our lasting commitment to our operators by having a strong (and growing) services presence, close to them.

**Could you describe the origins and service offering of ATR Singapore and outline your operations with the ATR Singapore Training Centre?**

**Christophe Potocki:** Incorporated in 1996, ATR Singapore (AES) is fully owned by ATR, the world's leading turboprop aircraft manufacturer. Despite the global economic challenges, we have continuously maintained our presence in Singapore to support our customers in the region. We have 50 talented employees in Singapore. Loyalty and dependability are the most important traits that customers seek in Asia Pacific; they are both key values within ATR.

Our main activities in Singapore focus on services to our customers. AES offers a

wide range of services, from training solutions for pilots and engineers to technical support (repair solution / troubleshooting) and spare part support (inventory management / power-by-the-hour system for maintenance [GMA]). In 2013, we invested in a multimillion dollar training complex in Seletar Aerospace Park, alongside Singapore Technologies (ST), to set up an ATR 72-600 Full Flight Simulator. It took us six months to go from zero to housing an ATR simulator. ST managed this incredibly successful project. Today, ST's simulator is operational over twenty hours per day. Singapore is also the home-base of our Sales teams in Asia Pacific.

**Why was the decision made to open a training center in Singapore and what are ATR Singapore's international growth targets?**

**Jean-Pierre Clercin:** ATR Market Forecast anticipates a need for over 1,000 aircraft within the next 20 years in the Asia Pacific region. Operators will all need pilots to fly all these aircraft. Having a dedicated train-

ing center was essential for us to meet the demand in the fast growing Asian market.

**Christophe Potocki:** There are not enough training centers in Asia Pacific at the moment. Asia represents a third of our worldwide fleet and counts over 50 customers and operators. ATR pilots are thus in high demand in the region. We deliver a third of our aircraft to Asia Pacific customers, particularly within emerging markets such as Indonesia, Myanmar, Malaysia, the Philippines and other areas requiring inter-island operations.

**What are your views on the current regulatory framework in Singapore to allow for growth and development within the aerospace industry? Are there gaps that need to be addressed?**

**Christophe Potocki:** Singapore is certainly willing to embark on positive institutional changes to support economic growth. This country is a great place to develop business and be close to customers in Asia Pacific. The EDB supported ATR Singapore with a tax scheme to finance one of

our multi-party projects. The Government certainly creates the right environment for industrial companies like ours.

**Jean-Pierre Clercin:** Singapore encourages a pro-business ecosystem. The aerospace cluster in Seletar is a great example of this. The government has played a key role in attracting major players of the sector to one single location. As the sourcing of skilled labor remains a challenge, there is a strong push for new courses and university partnerships.

**What advice would you have for other companies aiming to operate out of Singapore and where do you intend to take ATR Singapore in coming years?**

As countries in the region develop and modernize, the gap that currently makes Singapore stand out from the rest will certainly narrow. This means that continuous innovation is indispensable. ATR will continue to develop technologies and create new solutions for clients. At the moment, we are focusing on the creation of a low visibility navigation system.



## Christophe Potocki and Jean-Pierre Clercin

GM for Sales ASEAN & Pacific and Managing Director  
ATR EASTERN SUPPORT

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As countries in the region develop and modernize, the gap that currently makes Singapore stand out from the rest will certainly narrow. This means that continuous innovation is indispensable.

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# Ralph L. (Skip) Boyce

President  
BOEING SOUTHEAST ASIA



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The Boeing Flight Services Singapore campus is our largest aviation training facility in Asia and can train up to 6,000 airline pilots and technicians annually.

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## Could you provide a brief overview of Boeing Singapore and outline a few country highlights?

Boeing has a 70-year strong partnership with Singapore where it employs about 350 people. The island state is our Southeast Asia headquarters where operations range from commercial aircraft and defense procurement, services support and training, to advanced research collaboration with the public and private sectors. A key highlight in 2017 will be SilkAir taking delivery of its first 737 MAX aircraft. The regional wing of Singapore Airlines, SilkAir started its transition to an all-Boeing fleet when it took delivery of its first Next-Generation 737-800 in 2014. Singapore Airlines, another bellwether customer, will take delivery of the very first 787-10 in 2018. Singapore Airlines has ordered 30 787-10s. Scoot, the long-haul low-cost subsidiary of the Singapore Airlines Group, which took delivery of its first 787-9 in 2015, will eventually have 20 Dreamliners in its fleet. With its unparalleled fuel efficiency and range, the 787 family has opened more than 120 new nonstop routes since entering service in 2011 and today flies more than 530 routes around the world. Boeing Asia Pacific Aviation Services, a joint venture between Boeing (51%) and SIA Engineering Company (49%), will provide industry-leading engineering, repair and maintenance services for Boeing airplanes in the region. Another key highlight this past year was the Singapore Ministry of Defense announcement that it has awarded a contract to Boeing for the acquisition of CH-47F Heavy Lift Helicopters also known as Chinooks.

## The demand for aircraft and professional personnel in Southeast Asia will only increase over the next couple of decades. What are some of Boeing's projections for the region?

Boeing's Current Market Outlook forecasts that there will be a demand for 3,860 new airplanes, valued at \$565 billion in Southeast Asia over the next 20 years. According to the annual report, more than 75% of the airplanes needed will be for single-aisle airplanes, as we continue to see a rise in the number of low-cost carriers as well as strong annual traffic, with growth rates of 6.4% for Southeast Asia. We also forecast a demand for 248,000 new commercial airline pilots and 268,000 new technicians over the next 20 years in Asia-Pacific. China will lead the region with a demand for 111,000 pilots and 119,000 technicians, followed by Southeast Asia with 62,000 pilots and 67,000 technicians. The Boeing Flight Services Singapore campus is our largest aviation training facility in Asia and can train up to 6,000 airline pilots and technicians annually. It houses six 737, 777 and 787 aircraft type simulators with plans to add more simulators in 2017.

## Could you describe Boeing's presence within the space exploration industry segment?

Today, Boeing is building NASA's latest spaceflight to transport crew to and from the International Space Station (ISS) - the Crew Space Transportation (CST)-100 Starliner spacecraft, which will launch in 2018. This will be a global endeavor and there are opportunities for every country to participate. Today, 15 nations work to-

gether on the ISS, and NASA continues to look for additional future partners. We believe that putting humans on Mars will be a global effort and the more countries that invest in the future of human deep space exploration, the better.

## The Economic Development Board of Singapore has a strong push towards the implementation of robotics and automation within the aerospace industry. How is Boeing contributing to this?

As the world's largest aerospace company, Boeing is at the forefront of new technologies and the implementation of robotics and automation innovation. We believe that advanced manufacturing supports our competitiveness by facilitating higher and more efficient aircraft production rates. Besides helping increase our production rates, it reduces flow time and improves first-pass quality. The investment in advanced technology helps us increase our capacity to build more airplanes. For example, the Panel Assembly Line on the 737 program is a highly automated wing skin panel production system that consolidates assembly into an in-line flow using a pulsing line. In Singapore, Boeing works closely with the Agency for Science, Technology and Research (A\*STAR) on research projects of mutual interests in manufacturing automation, defect inspection, maintenance and materials development. We believe in finding the right balance between automation, robotics and manpower.

# Soh Chee Siong

CEO  
JEP PRECISION ENGINEERING



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The industry is currently moving towards a SMART factory concept, adopting automation and data driven systems to stay competitive in today's challenging environment.

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## JEP Precision Engineering has delivered precision machining solutions for over 25 years. Could you describe the company's relationship to JEP Holdings and outline your service offering?

JEP Holdings is a precision machining and engineering services solutions provider, with a primary focus on the aerospace industry. There are a total of three subsidiaries under the group: JEP Precision Engineering, Dolphin Engineering and JEP Industries. JEP Precision Engineering was acquired by the group in 2007 and is the group's main operating subsidiary. Accredited with AS9100, OSHAS, and NADCAP, JEP Precision Engineering produces high-level precision machine parts and our capabilities lie within machining high-tensile material such as inconel, titanium and stainless steel. Over the years, we have become established within the precision manufacturing industry and have evolved into a leading supplier that provides complete turnkey services for aerospace, oil and gas, electronics and machine tooling industries. From the machining and engineering of engine casings for the B777, A320 and B737, our business has expanded into other aerospace components such as landing gear components for the B787 and A350, as well as air management system components for the B787 Dreamliner. In line with our goal to move up the supply chain and to provide our customers with complete manufacturing solutions, a NADCAP accredited chemical processing facility was set up at Tanjong Kling in 2014 for the provision of secondary processes. The aerospace segment currently represents about 70% of JEP Precision Engineering's revenue.

## JEP Precision Engineering grew from 10,000 sq ft to 200,000 sq ft with the new factory acquisition. Could you describe the new facility?

With the rapid growth of the oil and gas, and aerospace industries five years ago, we started looking at expanding our operations. We considered various countries in the SEA region, but decided that Singapore was still the most suitable place for us to grow. We approached the respective government bodies that assisted us in securing an 18,502.10 sqm plot of land within Seletar Aerospace Park. We are currently in the process of moving and will be completely operating out of our new facility by the last quarter of 2017. This brand new facility will house a production space that is 80% larger than our current premises. Although there are no signs of the oil and gas industry recovering in the next year, the aerospace sector is still growing at a steady rate. Boeing has reported about 5-7 years of backlog in their orders and they are always on the lookout for suppliers to increase their capacity to be able to fulfill the demand.

## Manufacturing companies make up 10% of the Singapore aerospace industry and there is a strong interest in growing this segment of the market. What future trends do you expect to see in this realm?

I believe that manufacturing will continue to be a key pillar in Singapore's economy. However, Singapore is becoming a challenging market to operate in given the rising cost of living and salaries. Asia-Pacific countries with lower operating costs are able to offer much more competitive pricing.

To overcome this, we are continuously looking at ways for improvement and to increase productivity, keeping our costs competitive. The other challenge is the tight labor market, which has a huge impact on most Singapore companies. To overcome this challenge, we have a close working relationship with educational institutions. I sit in one of the committees that review the curriculum for our industry to promote precision engineering and hope it will be a way to attract the younger generations.

## Which are JEP Precision Engineering's targets for the next three years?

The industry is currently moving towards a SMART factory concept, adopting automation and data driven systems to stay competitive in today's challenging environment. For the next couple of years, we will be starting to introduce new technology concepts and equipment into our production. We will start by implementing automation on a small scale, such as robotic unloading and loading. Once the pilot run is successful, we will look at implementation on a larger scale.

We are installing two sets of flexible manufacturing systems (FMS), where two lines of five machines would be fully automated in our new facility. With this system in place, we will have less reliance on people and machine utilization will be improved at the same time. Keeping up with technology is no longer a choice but our key to survival in today's competitive market. I think the beauty of adopting new technologies in our operations, is that productivity and quality will be improved. Automated data collection will help us in making effective decisions within our business.



# Simon Wayne

General Manager  
BOMBARDIER



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Within 15 minutes of this facility, we have a whole ecosystem of support. Singapore allows Bombardier to return aircraft to service with quick turnaround times and efficient logistics.

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## Could you provide a brief overview of Bombardier Singapore's operations?

Bombardier is the world's leading manufacturer of both planes and trains, with revenues of US\$18.2 billion and over 70,000 employees worldwide. Bombardier Business Aircraft Singapore is a business aviation service center where we support Global, Challenger and Learjet aircraft. We established our operations here in 2013 to become a one-stop-shop for Bombardier business aircraft owners in the region. Bombardier Business Aircraft also has regional support offices in Mumbai, Shanghai, Hong Kong and Sydney, as well as parts depots in the region. Bombardier revenues (including its Aerospace and Transportation business segments) for 2015 reached US\$2.4 billion within the Asia-Pacific region.

## Bombardier aims to be the future of mobility for the SEA region. How will Bombardier work to attain this goal in terms of business aircraft?

The business aircraft segment of the industry has grown a lot in the last 8-10 years in the region. This aligns with the economic development and growth that companies have experienced, as well as the level of wealth within Asia.

The Global 7000 business jet's entry-into-service in the second half of 2018 will bring a class-defining product to market that will capture much of the protected growth within business aviation.

The Global is uniquely designed from the inside out to deliver a cabin experience like no other. Passengers will experience an impressive long-range capability. Our three families of business jets, Lear-

jet, Challenger and Global, represent the broadest offering of all business aircraft manufacturers and makes us well placed to continue growing as a driving force for mobility in the region.

## With over 4,000 employees in Asia, what is the importance of Bombardier for employment in the country and in what way do your operations help the skilled labor growth in Singapore?

Bombardier Business Aircraft Singapore employs an average of 130 people. We have built strong relationships with local polytechnics, technical institutions, and training schools in order to develop Bombardier Business Aircraft's staff with them. We invest long-term in order to create sustainable solutions. We also have yearly internships for 10 to 20 students from local aeronautical engineering courses, which last up to six months. The Singapore office will continue to grow with local emerging talent that we have cultivated for years. Our employees are the driving force behind Bombardier Business Aircraft's success and we have a strong focus on hiring the leaders of the future for our operations.

## Which are the key challenges and advantages operating within the Singapore market?

Singapore is a prime location in the region, with ease of access for maintenance and operations, zero tax and connectivity to all the major cities within the region and globally. It offers time-efficient customs clearance, which makes movement much easier than in other parts of the region. A quarter of the MRO market in Asia is contained within Singapore. Within 15 minutes of

this facility, we have a whole ecosystem of support. Singapore allows Bombardier to return aircraft to service with quick turnaround times and efficient logistics. The government is a strong player in the country; they truly focus on improving the system to benefit the industry and they have developed a very strong aerospace market in a very short period of time.

The educational system and language in the country are also strong selling points for Singapore. This makes it easier to do business and allows for expansion. The safety and security standards within Singapore provide strong stability for companies operating in the region. Like Canada, Hong Kong and Australia, Singapore is recognized as a world-class regulator. Certifications by CAAS are extremely well recognized globally.

## What are Bombardier Business Aircraft Singapore's key objectives for the next 3-5 years?

Our objective is to increase our capacity. We will be adding the Global 7000 aircraft to our approvals in order to support the new fleet coming into the region upon the entry-into-service of the aircraft. Within 3 years, we will attain an even broader portfolio of certifications, covering a wider area of maintenance and service. We aim to become a one-stop shop, building capacity to support an increasing fleet. We will maintain our fast turnarounds and our ability to support our customers 24/7.



# Ricardo Pesce

Managing Director  
EMBRAER ASIA PACIFIC

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We also see opportunities in emerging economies in the region. As each country's GDP grows, so will the appetite for travel. Over the next 20 years, Asia Pacific is expected to account for about two thirds of global growth.

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## Embraer has had a presence in Singapore for over a decade. Could you describe the reasoning for establishing an office in the country and outline a few recent key milestones?

In the mid 1990s, the USA was by far the largest market that we had, with Europe following as the second. We knew that we needed to diversify and made the decision to enter Asia and establish a strong presence in the continent. We opened an office in China, specifically for that market, and also in Singapore, because it is a hub for the rest of the Asia Pacific region. This has paid off given that for the last 16 years we have placed more than 330 airplanes in 17 countries in the region. We made a bold decision in 2006 to set up a regional distribution center for parts here. Embraer was the first large Brazilian corporation to set up shop in Singapore; there are now about 10 of them.

We are developing many products which are currently in testing phases to be released during 2018. We have developed seven new products on the business jet side since 2005. No other manufacturer has created that many models in 10 years. On the commercial aviation side, the E-Jets E2 program is underway. In the defense and security area, we are in the flight test campaign stage for the KC-390 – our new jet-powered medium air-haul aircraft. At the Farnborough Airshow in 2016, we made the debut of the E190-E2 first prototype and the KC-390, in addition to the Legacy 500 business jet. We are optimistic about the growth prospects in Asia Pacific and believe Singapore provides us a strong base to capture opportunities in the region.

## What are Embraer's target markets after Singapore and China?

There is a clear indication that the center of gravity for aerospace is moving from the USA towards Asia now. Singapore is an excellent place in which to do business and an ideal hub in terms of logistics, legal framework, safety, IP for R&D and IP protection. In terms of connectivity, one can fly all over Asia from here very easily. We also see opportunities in emerging economies in the region. As each country's GDP grows, so will the appetite for travel. Over the next 20 years, Asia Pacific

is expected to account for about two thirds of global growth. According to IATA, by 2034, nearly half of all air travel will touch the Asia Pacific region. Indonesia is an ideal market for air transportation because they have more than 17,000 islands and we see it as a prime example of a growth market.

## What are your views on the current regulatory framework in the ASEAN region to allow for growth and development within the aerospace industry?

There are discussions within ASEAN to bring the Open Skies Agreement to greater fruition. We are very hopeful that this will happen in the future, given that it would bring many opportunities for passengers. At the moment, most traffic is directed through the hubs in the region, such as Bangkok, Ho Chi Minh, Hanoi and other main capitals. With the Open Skies Agreement, there will be further connectivity opportunities into secondary and tertiary markets. This would generate many opportunities for smaller single-aisle jets like our E-Jets, which can better match capacity against demand. It will take some time for this to happen given that many countries are protective of their own markets, but given the economic benefits that await, we are confident that ASEAN's skies will be more 'open' in time to come.

## What is the importance of the Embraer's new developments with E-Jets in terms of environmental impact?

The whole purpose of developing the new family of E-Jets is to save on fuel consumption, so they are much more efficient and aerodynamic. We have one of the most fuel efficient airframes in the world (weight in relation to airplane payload). We design for efficiency and sustainability. Despite the current low oil price, we believe that it will eventually rise, reiterating the long-term need for fuel efficiency. Even as we work on our E-Jets E2 program, we have been using our existing E-Jets platform for the ecoDemonstrator program we are working on with Boeing. It is aimed at testing technologies to improve airplane environmental performance and accelerate their introduction into the marketplace.



# Growing the Landscape:

## From MRO to Manufacturing

By *Elisa L. Iannacone and Alice Pascoletti*

With 10% of the global MRO market share, Singapore has strengthened its nose-to-tail MRO capabilities for fixed and rotary-wing aircraft on the back of Asia-Pacific growth. Continued investment in the country's MRO capacity solidifies its international position as a hub for the region. Given that MRO needs will diminish with the lessening maintenance needs of new generation aircraft, the EDB is pushing the country to broaden its market and grow manufacturing capabilities. Comparatively to last year, Singapore's overall manufacturing output increased 11.9% in November 2016.

Currently, the Singapore MRO market has attracted companies such as Thales, Safran and Rockwell Collins for cockpit avionics, Panasonic and Jaco for cabin interiors, UTC Aerospace Systems for thrust reversers and landing gears, SIA Engineering and ST Aerospace for airframes, Meggitt and Liebherr for components, Honeywell and Pratt & Whitney Canada for APUs, and Rolls-Royce and GE Aviation for engines. Bell Helicopter, Safran Turbomeca and Airbus Helicopters lead the market for helicopters, and Hawker Pacific, Fokker, Cessna, Bombardier and Jet Aviation are the driving force behind business and general aviation in the country.

Within the engine MRO department, Eagle Services Asia for P&W Engine Overhaul, a JV between Pratt & Whitney and SIAEC, is the Centre of Excellence for PW4000 engines. The GE Aviation Services Network offers component support capabilities for multiple engines, and SAESL, the Trent Centre of Excellence, offers capabilities across a range of Trent engines. After-market services include conversions, modifications, refurbishments, supply chain management, spares distribution, pilot simulator training, service engineering, fleet management and

leasing.

The precision engineering segment has experienced an improved business environment with higher orders for semiconductor equipment. Continuous expansions in the MRO and after-market segments continue, with Airbus' launch of the Airbus Asia Training Centre (AATC), Safran opening a facility in SAP, and ST Aerospace establishing a VIP Aircraft Interiors Centre, all in 2016. However, the manufacturing segment is not lagging behind, housing world-class manufacturers such as Pratt & Whitney's GTF Engine Manufacturing Facility, Wah Son Engineering, which is commencing operations at its Seletar facility and JEP Precision Engineering, that also established a facility in Seletar. "I believe that manufacturing will continue to be a key pillar in Singapore's economy," said Soh Chee Siong, CEO, JEP Aerospace.

Aside from Singapore's strategic location in the region as a hub for major trade routes, the country has strong air connectivity, with the presence of multiple logistics providers that can assist with clearances and shipping, making it a top logistics center. Well-designed infrastructure and cutting-edge technology make Singapore a prime location to cut down times on shipments and handle increasing demands. "Shipments can be pre-cleared quickly and hassle-free via the online

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Lantal Textiles Asia Pacific analysed numerous options as possible locations for an Asian hub. Among them we studied Kuala Lumpur and Hong Kong, but Singapore's geographical location is truly unparalleled in the region. Transport facilities, infrastructure and international connectivity were also important to our operations. The fact that Singapore Airlines is one of our most loyal customers worldwide was also an influencing factor.

**Stefan Naf, Director Markets Asia Pacific, LANTAL TEXTILES ASIA PACIFIC**

customs system which operates round the clock. It is critical for customers to minimize the time aircrafts are immobilized on the ground and thus they value much more efficient logistic solutions in Singapore versus positioning such activities in low-cost countries," said Martin Habisreiter, director, Airfreight Singapore and Malaysia, Kuehne + Nagel.

With an array of Free Trade Agreements both within ASEAN and multiple countries in Asia-Pacific, air-freight providers can benefit from faster clearances, top-level security and a general ease of doing business. "Replicating this system in India or China would likely prove a fruitless task, as the Singapore government regularly puts forward 'friendly' policies which are conducive to continued growth," said DSRV Varma, head of operations, CYENT.

The race for developing the manufacturing industry in Singapore is on-going and various companies have been forced to seek support internationally in order to fulfill their operations in the meantime. "On a company scale, Thales' main constraint is that we still lack certain manufacturing capacity and services in-country, which leads us to source them internationally," said Ng Kim Keng, head of country business unit, Avionics, Thales Solutions Asia.

Thales in Singapore is currently building up local capabilities for avionics production and MRO. It is also developing competences within the supplier network and believes that Singapore will continue to turn challenges into longer term opportunities for the industry.

Although new products are being created, innovation also entails the customization of pre-existing products or the creation of more cost-effective solutions for the industry. The SMART city concept is continuously developed for Singapore

to maintain its technological leadership position in the Asia-Pacific region. Increased connectivity also means increased cross-investment between countries both in developing and emerging markets. Countries like Malaysia, Thailand, Vietnam and Indonesia are also supporting innovation but require higher levels of investment before they can compete as regional hubs. Singapore will continue developing advanced manufacturing technologies, such as additive manufacturing, robotics, automation and data analytics to continue pushing its industry into the SMART city concept. The manufacturing industry is a primary target for these new technologies, with the capacity to implement them in parts of their operations that require repetitive actions.

The growth in the industry across Asia-Pacific has led country leaders to take measures to prepare for the future. The Bombardier Service Centre (BSC) has established a comprehensive range of after-market services and is capable of performing light maintenance for their families of aircraft jets. JET Aviation increased its MRO capacity as well as increasing its capability to modify aircraft, complete avionics upgrades and interiors refurbishment. ST Aerospace is increasing its MRO capacity and Pratt and Whitney is acting as an OEM and MRO center in the country for its commercial aero-engine products.

Although there is still a need for MRO capabilities in the region, overcapacity within the sector remains a concern given that many new facilities have been launched in anticipation for new aircraft deliveries. Less maintenance is required in newer generation aircraft and therefore the need for MRO might be less than predicted. Nevertheless, the need for airports to expand in the region to meet the growing demand is pressing. "It is important that governments continue to invest in expanding airports as well as other areas such as MRO and training. We need to stay ahead of the curve[...]. Even though the rate of passenger traffic growth has slowed in recent years, it is paramount to continue to look at the bigger picture and invest to ensure that we do not create a scenario where capacity growth stops," said Brendan Sobie. —

# Thales in Singapore

## Wherever safety and security matter, we deliver

### AEROSPACE

Making air travel safer, smoother, environmentally cleaner and more enjoyable

### SPACE

Optimising solutions for telecoms, earth observation, navigation and research

### SECURITY

Helping to protect citizens, sensitive data and critical infrastructure

### DEFENCE

Improving decision-making and helping forces gain operational superiority

### GROUND TRANSPORTATION

Enabling networks to run more swiftly, safely and at higher capacity

Thales has been an integral part of life in Singapore for over four decades. We innovate with our customers to design and build leading-edge solutions that help to protect people, infrastructure and the nation. Locally, we employ more than 600 people in Singapore in the specialist domains of Avionics, Security, Transportation, Space and Defence. Every moment of every day, wherever safety and security are critical, Thales delivers.

Search: Thalesgroup



**THALES**  
Together • Safer • Everywhere



# NG Kim Keng

Head of Avionics  
THALES IN SINGAPORE



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We continue to develop and increase the competencies within the supplier network in Singapore and we collaborate with some of our partner companies to grow the repair capabilities in the region.

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**Thales has been present in Singapore for over 40 years. With a presence in various countries in Asia, what is the importance of Singapore for Thales?**

In terms of aerospace, Singapore has been a paramount MRO hub for Southeast Asia (SEA) and Asia-Pacific. It is considered to be the center of connectivity for air and maritime routes, as well as having the right language, infrastructure and ease of doing business for aerospace. Maintenance activity in the country is key for economic development and job-creation. For several decades, the government has launched programs to incentivize companies like Thales to establish operations within Singapore. A high value is placed on transparency and reliability, which are indispensable traits for the aerospace industry's demands. We work closely with Singapore's Economic Development Board (EDB) for the growth and development of programs within Thales in Singapore.

The workforce in Singapore is reliable given the high level of education that can be found in the country. Singapore is a hub for industrial manufacturing and the aerospace industry needs this kind of competency, which is why we have been growing in Singapore since 1981. We also oversee a satellite operation in Beijing from here, which serves local airlines in the Chinese market.

**Could you outline the Thales Group's key service offering for the aerospace industry in Singapore and the SEA region?**

We started operations by serving airline customers as a customer support service center. We have now set up our own capac-

ity to repair equipment on-board aircraft in Singapore and act as a regional repair center for Asia-Pacific. Given our success with repair operations, we also decided to establish a production facility in the country some six years ago, where the avionics products produced here in Singapore are now shipped to companies like Airbus and Boeing directly. The production center leverages a network of suppliers in emerging countries such as Thailand, Malaysia, India and China as well as established markets like Japan and Singapore. We have been very successful in developing suppliers in these countries as an alternative to our traditional market. We institutionalize the supplier qualification process and requirements within the network, and put in place a strong partnership program with the suppliers to ensure smooth delivery of components and parts to our production center. We benefited from the support of the EDB to build on this successful operation.

**How does Thales in Singapore support Singapore's Ministry of Defense?**

We have developed two types of activities alongside the Singapore defense sector. The first is to take care of basic research and technology operations that can be applied to the Ministry of Defense's operations. The second is to promote and propose defense systems for the sector, based on import technologies. Thales does not develop any hardware or software in Singapore, which means that we need to import nearly 100% of our proposed solutions. We also run a Research & Technology (R&T) center, which was set up more than 10 years ago with some funding from the defense sector, to perform research for

their communications division. Thales has focused on underwater communications systems and has supplied hardware and software solutions that were co-developed with the Singapore Defense Agency.

**How does Thales assist Singapore in building up local industrial capabilities for avionics production and MRO?**

Thales is strongly committed to further Singapore's goal of acting as a regional center for innovation within the aerospace industry. We continue to develop and increase the competencies within the supplier network in Singapore and we collaborate with some of our partner companies to grow the repair capabilities in the region. Thales also runs an Innovation Hub in the country, which engages customers and partners in user-centered innovation, enabling cross-functional collaborations for co-designing, prototyping and testing new concepts across areas ranging from defense and maritime security, to aerospace, air traffic management and smart cities.

**What is your vision for Thales in Singapore over the next 3-5 years?**

Our avionics and aerospace businesses have been growing at an annual rate of 6 to 8%, in terms of activity and revenue, and we have achieved over US\$200 million in sales revenue on average each year. Five years from now, I envisage having more synergies in place for MRO and production activities in the country. We will also explore the additional value that Thales can provide to local customers, including getting closer to the early phase of product development and developing new services for the market.

# Bicky Bhangu

Director  
SINGAPORE, ROLLS-ROYCE



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Our Singapore footprint contributes to the global Rolls-Royce Research & Technology strategy. We have an extensive research footprint in Singapore in the area of manufacturing technology, electrical systems and digital systems.

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**Could you provide a brief overview of Rolls-Royce in Singapore and outline your offering for the aerospace industry?**

Rolls-Royce operates internationally with five strategic 'home countries': the UK, the US, Germany, Norway and Singapore. In Singapore, we have a significant footprint at the Seletar Aerospace Park. Our 154,000 sqm Seletar Campus is an integrated facility where we manufacture wide chord fan blades, assemble and test Trent engines, conduct our employee and customer training, and have a focused customer service center for our Asia Pacific airline customers. This is complimented by our MRO joint venture in Singapore, SAESL, providing support for the full lifecycle of an aero engine. Together this totals 1,500 employees working in Singapore, which added to our JV, becomes a pool of 2,500 people in total.

When we opened our Seletar Campus in 2012, it marked a significant milestone for Singapore's aerospace industry – Singapore can say that it makes, flies and service engines. It's worth highlighting that our Singapore footprint contributes to the global Rolls-Royce Research & Technology strategy. We have an extensive research footprint in Singapore in the area of manufacturing technology, electrical systems and digital systems.

While 90% of our operations in Singapore are related to the civil aerospace market, we also engaged with the defense sector.

**Why was Singapore selected as one of Rolls-Royce's 'home country' markets?**

Over half of our civil aerospace order books come from Asia and the Middle East, so it's important for us to have a pres-

ence that's close to our customers. It is also vital to our business model as 50% of the overall Rolls-Royce revenue comes from after-market services and support. Consequently, we understand the importance of a regional hub to the success of our customers' operations.

Our commitment is supported by Singapore's very clear and structured national strategy which puts aerospace at the forefront of future development. The fact Singapore has strong governance, transparency, and a highly skilled workforce all contribute to Singapore being one of our strategic locations.

**Could you describe the reasoning behind Rolls-Royce's partnerships with local universities and research institutions?**

In order to keep developing the most cutting edge technology we need to work with the brightest and best minds from specialist universities globally. Rolls-Royce invested £1.2 billion on R&D in 2015, and has established a network of 31 University Technology Centers worldwide, of which Nanyang Technology University (NTU) is one of. So we collaborated with NTU to form Rolls-Royce@NTU Corporate Lab. We have more than 2,000sq m in Singapore allotted for laboratories for data analytics, repair, electrical systems and manufacturing. At the same time, we believe that getting involved with partnerships with universities and research institutions will help nurture talent and inspire the next generation of future engineers and scientists. We take around 100 interns every year into our Singapore workforce. This is vital to ensuring a consistent and highly skilled talent pool not just for us, but also for the wider industry.

**Could you provide an overview of the digital activities that Rolls-Royce is involved in?**

Rolls-Royce supplies a broad range of services within the digital sector, from sensor technologies, software and connectivity, to improving productivity in the factories of the future. Building on our expertise in civil aerospace, where we are already using Big Data in our TotalCare services We are also developing ship intelligence; we are pioneering the technology behind autonomous vessels, utilizing IoT (digital connectivity), which can be remotely controlled. One of the major challenges in the digital field is creating adequate algorithms that can integrate the whole value chain. Rolls-Royce is adding value as a systems integrator, which is why we are seen as a strong partner in the country. We are starting to develop predictive rather than reactive maintenance. The ultimate target is to develop the technologies of the future by embracing digital, automation and robotics developments, which will add value to our operations.

**Which are your key objectives for Rolls-Royce in Singapore, for the next 3-5 years?**

I would like to see our Seletar Campus' facilities operating at 100% capacity: producing more than 8,600 fan-blades per year, assembling our target of 250 engines / year and assembling a new engine type. We are already in pre-production phase with the Trent 7000 and will start production in 2017.

We want to maximize our digital technologies that will improve and develop our products, services, factories and processes.

# Lim Serh Ghee

President  
ST AEROSPACE



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MRO in the future will evolve along the features of the newer airplanes, as the focus shift towards a smarter and more data-centric maintenance regime.

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**ST Aerospace has a global network to assist clients across a full range of services. Could you describe the service offering that you provide?**

ST Aerospace has presence in the US, China, Europe, Australia and Singapore. In 1975, we started in Singapore to support the Republic of Singapore Air Force (RSAF) with their aviation maintenance requirements. From that strong engineering foundation, we have grown the business in MRO in tandem with the growth in global commercial aviation to a portfolio that is about 30% military and 70% commercial by revenue. Our service offerings as ST Aerospace group of companies include aircraft maintenance and modification, component total support, engine total support, aviation and training services, and aerospace engineering and manufacturing. These five clusters of capabilities and competencies allow us to offer to our customers the spectrum of engineering and maintenance solutions.

With more than 40 years working on both military and commercial aircraft, engines and components, we have the engineering depth and expertise to provide repair and engineering solutions that are tailored to the requirements of our customers. We develop value-added solutions for our customers that can range from engineering design to modify an aircraft fleet, for instance passenger-to-freighter conversion, to designing and manufacturing aviation products such as aircraft seats. Another attribute that differentiates ST Aerospace is our work involving both military and commercial aviation, and with it, our work culture has strong focus on technical competence, timeliness and dependability.

**ST Aerospace is a part of ST Engineering, a homegrown defense and engineering group with three other strategic businesses in electronics, land systems and marine. How does ST Aerospace leverage the synergy within the group?**

For customers that require integrated and networked solutions spanning the air, land and sea domains, we are able to leverage synergies within the ST Engineering group to deliver such solutions. As the unit with air platform expertise, ST Aerospace will lead in unmanned aerial vehicle (UAV) projects while the land system unit, ST Kinetics, will lead the autonomous ground vehicle projects, and the marine unit, ST Marine, in sea platforms. The electronics unit, ST Electronics, with its strengths in communications, software and intelligent systems, can develop the intelligence in the platforms. One example of collaboration is a UAV developed by ST Aerospace that can be launched from the rear of a vehicle developed by ST Kinetics. Beyond collaborating on product design and development, the strengths of ST Engineering can also be harnessed to help the group innovate and perform better in the delivery of services to our customers. For instance, we are working on using data analytics more in our operational processes to improve decision-making as well as automate some of our work processes to benefit from unmanned operations where suitable.

**What kinds of trends have you noticed in the MRO segment and what changes do you see moving forward?**

The global MRO spending continues to be strong. In the next 10 years, spending is expected to achieve a compounded annual

growth of 5.7% to US\$66 billion. Of these, the largest segment is for engine repair overhaul, for which material costs will be dominant. As new aircraft are inducted with newer technologies and better efficiency and reliability, the maintenance needs will also change. The traditional heavy checks cycle will become less dominant as new generation airplanes require less labor during scheduled maintenance, which will also happen at longer intervals. MRO in the future will evolve along the features of the newer airplanes, as the focus shift towards a smarter and more data-centric maintenance regime. Beyond the system-level troubleshooting, the more detailed level of MRO will have to evolve to become more efficient by using smart diagnostics to troubleshoot, and automation to reduce the human work effort. This points towards the need to invest more in robotics, analytics, data communications and systems thinking to be able to effectively manage and innovate processes to maintain onboard smart systems.

**What is the future outlook for ST Aerospace and which milestones do you hope to achieve in upcoming years?**

ST Aerospace will continue to leverage its engineering capabilities to create more intellectual property that will be a part of its range of products. The hallmark of aviation has always been about being airworthy and safe operations. As an MRO service provider, ST Aerospace is certified by international airworthiness authorities, such as the CAAS, the FAA and EASA, to be compliant and world-class. We will continue to improve ourselves to serve our customers with utmost professionalism and best standards.

# John Riggir

Vice President and General Manager,  
JET AVIATION SINGAPORE



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Doing business here, in terms of access to airport facilities and services companies, is easy.

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**Jet Aviation has been providing services to customers in Singapore for 20 years. Could you describe your international operations as well as your vision for Singapore?**

Jet Aviation is headquartered in Basel, Switzerland and is part of a Fortune 500 company called General Dynamics (GD). Jet Aviation represents one arm of the aerospace investments division within GD. As a leading business aviation services company, Jet Aviation's service offerings include maintenance, completions and refurbishment, engineering, FBO and fuel services, along with aircraft management, charter and staffing. From a service perspective, we have an integrated “hub and spoke” business service model, operating four major MRO hubs — located in St. Louis, Basel, Dubai and Singapore — which are supported by other global maintenance facilities to meet regional demand. Our two Completions Centers are based in Basel and St. Louis, while we operate 20 FBOs around the world and manage a global fleet of approximately 300 aircraft.

Jet Aviation launched its MRO & FBO facility at Singapore Seletar Airport at the Singapore Airshow in February 1996.

The business aviation market is certainly growing in Asia-Pacific and we have faced accelerated growth ever since China started buying large jets in 2010. Jet Aviation built a new facility in 2014 adjacent to our old hangar, and we are building a new hangar in Singapore now, which will be completed in Q3 of 2017. Overall we will grow to occupy a space of about 15,000sq m, firmly establishing Singapore as a major hub for Asia-Pacific.

**Could you describe your service offering for the aviation market in Singapore?**

Jet Aviation is a multi-faceted business aviation services company. We want our customers who own a private jet to have the possibility of having it serviced anywhere. From a services perspective, we are divided into aircraft completions (for large aircraft), maintenance and refurbishment services, FBO (ground handling), aircraft management (owning, crewing, flight planning, provisioning), and we also operate alongside Jet Professionals, which is a staffing company that provides all the personnel needed to provide high-standard services to our clients.

**How does Singapore's aerospace industry compare to Hong Kong's?**

In terms of business aviation, the rules and regulations are basically the same in both Singapore and Hong Kong. As far as running a business in those locations, Hong Kong airport has become congested. When the planning of that airport was done, they catered for what they believed would be the largest private-jet market possible, about 30 aircraft, whereas there are well over 100 aircraft parked there. The infrastructure to support business aviation there is complex and now restricted given that operators are all competing for limited space and landing permits along with the growth in demand in commercial airline activity. Hence our strategy to expand into Macau, which will provide us with a great deal more flexibility and opportunity for growth of our operations in the future.

In Singapore the Economic Development Board is playing a very influential role in terms of land allocation and usage. They

are very proactive in promoting Seletar Aerospace Park and have a strong vision to create business aviation services that are unrivalled in the region. Doing business here, in terms of access to airport facilities and services companies, is easy.

**What is your opinion on the Singapore EDB's strong push for the implementation of robotics and automation in the aerospace sector in Singapore?**

From my prospective, it will take an incredible amount of alignment with the manufacturers and regulators to successfully implement robotics and automation into aerospace operations. Jet Aviation's operations would have to be sized and coordinated to address several models of aircrafts and, given that cost and complexity, AI would not be our main focus at present. Jet Aviation already implements advanced technology in terms of 3D mapping to produce aircraft interiors, which allow us to design, construct, assemble, test and certify a complete interior stage by stage — and much faster compared to what we could do just three years ago. We are now able to create a full Boeing business jet interior in six months. State of the art 3D engineering and manufacturing aid us in cutting honeycomb panels with laser or water-jets in a synthetic environment for ultimate accuracy. Real advantages will be felt in terms of aircraft assembly, where skilled labor may be replaced by automation in the future, but aircraft maintenance will take longer.



# Leow Thiam Seng

Group Director of Cluster Group  
JTC



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The clustering of aerospace companies also opens up more opportunities. Being in SAP brings them closer to their customers, which helps to improve business linkages and operational efficiency.

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**Could you provide a brief background of JTC's history in Singapore and outline your key objectives within the aerospace industry?**

Set up in 1968, JTC is the lead government agency responsible for the development of industrial infrastructure to support and catalyze the growth of industries and enterprises in Singapore. Landmark projects by JTC include the Jurong Industrial Estate; the Jurong Island for energy and chemical industries; business and specialized parks such as Airport Logistics Park of Singapore, International Business Park, Changi Business Park, CleanTech Park and Tuas Biomedical Park; a new work-live-play-&-learn development called one-north; and the Jurong Rock Caverns, Southeast Asia's first commercial underground storage facility for liquid hydrocarbons. JTC also develops innovative space, such as JTC Surface Engineering Hub, JTC MedTech Hub and JTC Food Hub, which incorporate innovative features and shared infrastructure to enable industrialists to start their operations quickly and enhance productivity.

**Could you describe JTC's developments and future outlook for Seletar Aerospace Park?**

Seletar Aerospace Park (SAP) is one of JTC's iconic developments dedicated to the continued growth of Singapore as an aerospace hub. Since its inception in 2007, SAP has developed into a world-class integrated aerospace hub hosting a wide range of aerospace-related activities.

SAP spans 320 hectares of purpose-built land and infrastructure, including the Seletar Airport. Today, SAP is home to more than 60 companies, with a mix of MNCs,

including Rolls Royce, Pratt & Whitney, Airbus Helicopters and Bombardier, and local SMEs. There is a thriving aerospace community of almost 5,000 working professionals in SAP.

**Could you speak of the success that SAP has had in developing the aerospace ecosystem?**

SAP is able to help the aerospace industry attract their supply chain to form a comprehensive ecosystem, which in turn grows the number of good jobs for the industry and Singapore. The co-location of SMES and MNCs in SAP creates more opportunities for networking and business collaborations, thereby enhancing the competitiveness of the aerospace industry. The establishment of the Rolls-Royce Seletar Campus, besides attracting correspondingly world class supporting suppliers such as RLC, has also generated positive spinoffs and expansion into SAP by local companies such as JEP Precision Engineering, who manufactures Rolls-Royce engine casings and rings for Trent engines.

Wah Son is a key instance of an SME whose strategic establishment in the SAP has aided in enhancing its growth as well as the ease of integrated business collaboration with aerospace MNCs. Established in 1971, Wah Son has evolved from a traditional family-run machining workshop to a global leading aerospace engine tooling manufacturer. Moving into the SAP in July 2015 was an important enabler for Wah Son to continue expanding and developing its capabilities. Wah Son has since established new partnerships with Pratt & Whitney, Bombardier and Vector Aerospace in the estate to provide tooling solutions, signifi-

ing how being in SAP has aided Wah Son's progression.

SAP provides industrialists with the necessary supporting infrastructure and allows them to seize potential synergies by being clustered together. Being in SAP brings them closer to their customers, which helps to improve business linkages and operational efficiency.

**Beyond infrastructure, JTC is building a strong knitted community in SAP, could you speak of this?**

The next stage of SAP's development focuses on deepening business relationships and creating a sense of belonging and identity; building a community that is greater than the sum of its parts. To create a vibrant community, JTC organizes regular events for the SAP community including networking events, lunchtime talks and exercise classes. Focus group sessions are held regularly to engage and understand the needs of the community. These initiatives provide companies with the platform to network, setting the stage for possible collaborations. JTC also works closely with companies and the industry association, Association of Aerospace Industries Singapore (AAIS) to strengthen business linkages between companies. Most recently, we worked together with AAIS and other government agencies to showcase local companies in a trade exhibition in France. We are in discussion with AAIS to run courses pertaining to aerospace certification, safety regulations, and general skills upgrading for the aerospace community. JTC will continue to develop new and innovative space solutions so that SAP can continue to support Singapore's aerospace industry.



Image: Hawker

## Navigating the Skilled Labor Shortages

By Elisa L. Iannacone and Alice Pascoletti

The Singapore aerospace industry currently employs 19,900 workers and is committed to developing the necessary talent to meet the industry's growing needs through the expansion and support of educational institutions. New courses and specialized programs are emerging to support the more than 1,700 yearly graduates in the aerospace sector. Although educational institutions have grown to attract international students and Singapore has evolved to become a training hub for the region, the country is still struggling with satisfying the need for skilled labor in its own aerospace industry.

A general sentiment that the Singapore graduate does not want to work his way up the work-ladder and tends to want to have a high-paying job from the start is shared across the industry. "In Singapore, younger generations nowadays seem to loathe manual work that may get their hands dirty. There is an overarching feeling that starting from the ground up is not worthwhile," said Lee Swee Meng, general manager, Composite Technology International. The rapid increase of aviation businesses also means that demand for skilled labour is higher, and employment costs continue

to rise. Employees have a tendency to go between companies looking for a higher-paying job or a better offer. "We end up with a pool of people that are simply transitioning from one business to another. The concern is that whilst this practice drives up the cost of skilled labor, it can be perceived as a generation that has less loyalty to the companies that offer them opportunities," said Nick White, managing director, Fokker Services Asia.

Despite the fact that many companies feel that high-turnover rates are experienced within the aerospace industry, others disagree. "It is not correct to say that there is a constant turn-over of employees. The aerospace industry, in particular, is known for its ability to retain its employees and provide good career opportunities. In fact, it is the sector with one of the highest percentages of local employees – around 80%," said SIA Kheng Yok, chief executive, Association of Aerospace Industries, Singapore.

Despite these opposing views, it remains clear that the sourcing of skilled-labor in the country has yet to stabilize and there is not yet a strong enough skilled-labor pool to meet the industry's demands. Ris-

ing costs have also extended to running a business in the country. Not only are employees' salaries higher, but a major challenge faced, particularly by the SME segment, is the rising cost of space rentals. The government's push for improving operations and processes through automation to cut-down on labor costs is a part of Singapore's solution to the problem. "[We must] upscale the workers rather than replace them. Let robots do the basics," said Philip Sung, director, sales & operations, Esterline Advanced Sensors.

Though the Singapore economy is primarily made up of SMEs and efforts are constantly made to set up grants and subsidies for these companies, it is paramount to improve on productivity by retaining the workforce on key roles and implementing Industry 4.0 in the work-space to keep up with the aerospace industry's growth pace. Younger generations are attracted to technology and innovation, which is another reason to push new processes forward. "We need to make the aerospace sector especially appealing given that most Singaporean graduates choose to go into what they perceive as more lucrative fields such as business. Working on an aircraft, engine

or car is not viewed as prestigious. We need to introduce the concept of technicians into Singapore in order to continue growing the industry,” said Patrick Garez, managing director, Asia Technical Services. Given the shortage of skilled labour in the country, many companies in the aerospace industry are forced to look for alternate means to meet their needs. “We are currently hiring employees from even our customers,” said Yap Siok Leng, finance controller, customer service & support, Meggitt. Others have started to question if their operations would benefit from holding operations internationally, given that the cost of labour is so much lower in the surrounding emerging markets, such as The Philippines, Malaysia and Indonesia. “The main driver for our business is not so much labour costs, but rather access to the talent pool. Certainly, labour cost is something we have to manage and there is a tendency to look for alternate locations to manufacture more cost-efficiently,” said Tan Kai Hoe, president and chief executive officer, Accuron Technologies. “The government in this country needs to think about how it brings more Singaporeans into aviation before the only thing we can do is bring in more local labour,” added Nick White. Companies looking to source labour internationally are primarily interested in

“ It is not correct to say that there is a constant turn-over of employees. The aerospace industry in particular, is known for its ability to retain its employees and provide good career opportunities. In fact it is the sector with one of the highest percentages of local employees – around 80%. ”

**SIA Kheng Yok, Chief Executive, ASSOCIATION OF AEROSPACE INDUSTRIES (SINGAPORE)**

“ The Boeing Flight Services Singapore campus is our largest aviation training facility in Asia and can train up to 6,000 airline pilots and technicians annually. It houses six 737, 777 and 787 aircraft type simulators with plans to add more simulators in 2017. Another unique feature is that the facility has a composite training workshop. ”

**Ralph L. (Skip) Boyce, President, BOEING SOUTHEAST ASIA**

geographical closeness, and many also, in developing partnerships and collaborations that can invest in growth as joint ventures. “Singapore is in a strong position given that it is surrounded by countries in the region where people are happy to come out to work. We are able to source manpower from Malaysia, Philippines and Indonesia if need be,” said Kelvin See, VP business development, Dedienne Aerospace. At the same time, others are concerned with the level of expertise they may find in markets outside of Singapore. Some have concluded that the best course of action is to remain local and pay more for the guarantee that the work-force they hire will be kept to a professional standard. “The simple fact of operating out of Singapore offers confidence and assurance [...]Operational and



Image: JEP Precision



## Louis Leong

**Vice President Asia HAWKER PACIFIC ASIA**

“ Customers are growing increasingly aware of how using a business aircraft can increase their productivity when pursuing business interests in emerging economies – this can be seen from increasing sales of business aircraft for personal use, particularly in Indonesia. ”

**Hawker Pacific has a strong presence in Asia Pacific. Could you describe your presence in the region and elaborate on the services offered to your clients?**

Hawker Pacific was established in Australia, and started its operations in Singapore by providing technical consultation for the Republic of Singapore Air Force back in 1969. Since then, the company has grown, establishing a technical support facility in Singapore and growing this over the years to become one of the largest maintenance, repair and overhaul (MRO) operators in Singapore’s Seletar Airport, providing maintenance, modifications, upgrades and other aircraft support services. We are now fleet-support market leaders for civilian and military aircraft and our dedicated team can provide integrated solutions across the value chain of aviation. We have aircraft maintenance facilities located across the Asia Pacific region in Singapore, Malaysia, Philippines, China, Australia and New Zealand, supporting some of the largest business and general aviation manufacturers such as Beechcraft, Bell Helicopters, Bombardier, Cessna, Daher-Socata, Dassault Falcon Jets, Diamond, Embraer Executive Jets and Hawker. Fixed Base Operator (FBO) and handling services are also available at our locations in Singapore, Shanghai, Perth, Cairns, Sydney and Brisbane.

Hawker Pacific also offers aircraft sales, aircraft management, special missions support and component repair out of Australia, and spares distribution through our warehouse in Hong Kong. We also have representative offices in China and Indonesia, and a facility in Dubai, which offers rotary-wing maintenance and component support.

**What kinds of trends for business aviation have developed in the Asia Pacific region over time and what key drivers will we see for the segment’s continued growth?**

The key drivers for the growth of the business aviation sector will be the increased demand stemming from countries that have a sizeable aircraft fleet, such as China, Indonesia, and even Malaysia. Customers are growing increasingly aware of how using a business aircraft can increase their productivity when pursuing business

interests in emerging economies – this can be seen from increasing sales of business aircraft for personal use, particularly in Indonesia. Business owners recognize that the aircraft is a business tool, allowing them to connect between continents and places which may not always have well-established commercial transportation links, and this allows them to save on time which they value above all else.

**Could you highlight Hawker Pacific Singapore’s key objectives for the next 3-5 years?**

We are increasing sales and the geographical reach of our aircraft support services, and growing and investing in our pool of skilled labor which currently sits at approximately 150 people. We work alongside the Singapore government to attract the younger generations into business aviation, which remains a niche segment of the market. It is a key growth area which has witnessed many polytechnics offering aircraft maintenance and aerospace-related courses over the past five years. Hawker Pacific is looking into developing new opportunities in-country and throughout the SEA region. We are always open to partnerships and joint ventures wherever the demand requires it.



# Jerry Liang



Executive VP and Accountable Manager  
**EXCEL AEROSPACE**

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We need to build up rather than out, by exploring innovation and developing workable processes to face new challenges.

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## Could you provide a brief background of EXCEL Aerospace and highlight the aircraft interior projects you are currently working on?

Excel Aerospace is a Singapore-based, approved MRO that focuses on supporting both operators and hangars in the region as an economic-solutions support-shop. We have a decade of experience and a very strong delivery history. Excel Aerospace started as an aircraft interiors shop, and this capability remains its core business, with constant projects and cost efficient overheads. Our business mission is to let our customers know that we provide products and services at European quality standards, but at Asian pricing. We have a strong interest in maintaining a certain quality of image. When people walk into our offices they can tell they have been exquisitely designed, and we want them to feel the same way when they enter an aircraft interior we have been in charge of designing. We have a turn around time for our customers that is much shorter than our competitors.

## How does Excel Aerospace source new clients and partnerships?

In this industry one gains customers through word of mouth. By managing our overhead and operational costs well, and keeping a high standard in all our deliveries by investing in skills, automation, and support logistics, we are able to offer our customers a competitive edge when they compete for projects. We work closely with our customers to listen to their challenges and needs. Excel Aerospace will then fine tune its activities and capabilities to support their needs and to allow our

customers to concentrate on other priority matters.

## Excel Aerospace is growing at a rapid pace, could you describe your near-future expansion plans?

Excel Aerospace is moving into the next phase of growth at the moment. We have invested in a 3/4 hectare of land at Seletar Airport, which will become a 4 story building and 11,000 sqm facility. Excel Aerospace would like to work with other companies that want to expand in Asia in order to develop synergies with new partners. We can grow organically to a certain level, but then we need to rely on partners in order to continue expanding to meet the growing demands in the region.

## Do you expect your operations to grow alongside the demand emerging in the Asia-Pacific region?

The Asia Pacific region will be the economic centre of gravity for at least the next 20 years. The percentage of growing nations is vast, such as Myanmar, Cambodia, Laos, Philippines, among many others. Asia has three of the world's largest populations. Borders in the region are not like Europe or even America, where one can drive across long stretches. In Asia, travelling northwards on land is a challenge, due to its many borders, uneven terrains, underdeveloped roads and security levels. These issues will take a long time to be addressed. From West to East there are the Himalayas. If we attempt to go by sea, we have the typhoon seasons and also piracy problems that we are trying to resolve. Sea routes currently are mainly freight only, we see very little or no services for passenger travel. The only way to move the

masses in the region is by air. Demand for aircraft will increase and we expect to have a strong presence in this rapid growing market.

## What challenges are MROs currently facing?

I think MROs have to change their mindset to become more competitive. I saw the glory days in this region – everyone was making good money, airlines were happy, even when oil prices skyrocketed, everyone was good. Most aerospace businesses today in Asia are expanding sideways rather than vertically, regardless if these expansion plans are repetitive or duplicating others. Without steady jobs and a commitment to grow, cost will surely go up with added depreciation and low productivity. Therefore, we need to build up rather than out, by exploring innovation and developing workable processes to face new challenges.

## EXCEL Aerospace holds certifications from the FAA, TA-M, as well as the VAR 145. How challenging was it to receive a certification from the CAA-S comparatively?

Basically because we are an SME, we had to approach the goal of attaining the various Airworthiness approvals carefully. The cost of getting them is not cheap, while maintaining them is another challenge. We have a strong commitment to ensuring that the entire company will work as a team, and that the management team is able to lead every department with knowledge and wisdom, ensuring all regulations and policies established by the authorities are adhered to and practiced.

living costs are also high, but these are tied to quality assurance, which is more of a positive feature,” said Darrel Chua, general manager, Flightech Systems. Looking at neighbouring countries in the region for labour can also pose the challenge of ensuring that work visa requirements are met. Companies seek as far as Australia, New Zealand and in certain cases across other continents. With an expertise in immigration law and foreign policy, companies such as ALG have emerged to assist customers in these kinds of processes. “Every country has a restriction on international staff and Singapore is no different to Australia when it comes to this,” said Tom Dowdall, chief executive officer, ALG. In terms of the future outlook for the labour costs in the region, Tom believes that “labour costs will inevitably continue to ramp up in Singapore, which is the nature of the industry here, as well as a challenge.” The strategy is to ramp up production through automation and sourcing the right skills for the job.

The push for manufacturing has attracted industry giants like GE, Rolls-Royce and Pratt & Whitney into Singapore, which triggers a mixed demand for labour, with a need for tradesmen as well as high-level licensed engineers and executives. Finding tradesmen remains the biggest challenge for the industry but the government identified this gap in the value chain a few years back and has set in place various programs to try and address the issue in time. Engineering shortages can also be felt across the industry. “Today the industry is very heavily loaded with technicians but not with sufficient engineers. SIAE has a mission is to build a technology and safety culture for the ‘Next Generation Aviation Profession’ to grow,” said Lim Yeow Khee, president, Singapore Institute of Aerospace Engineers.

Singapore, as a small island, will always have limitations, but progress is being made. In the same way that a S\$76 million (US\$53 million) investment was made into a Precision Engineering manpower initiative, and then supplemented in 2012 by another S\$36 million (US\$ million) for Precision Engineering Vocational Continuing Education & Training (PEVC), investments are currently being made to develop a sustainable pool of master craftsmen in the country. —

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Singapore is a small place with 5.5 million people, which includes foreigners. There is a tight quota on foreign hires and it is getting increasingly difficult to hire locals who are interested in this line of work. To overcome this challenge, we have a close working relationship with educational institutions. I sit in one of the committees that review the curriculum for our industry to promote precision engineering and hope it will be a way to attract the younger generations.

## Soh Chee Siong, CEO, JEP PRECISION ENGINEERING

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A challenge with Singapore is that with the rapid growth of aviation, many businesses are struggling to recruit local staff who have the experience needed. We end up with a pool of people that are simply transitioning from one business to another. The concern is that whilst this practice drives up the cost of skilled labor, it also leads to a growing population who may be perceived to have less loyalty to the companies who offer them opportunities?

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## Nick White, Managing Director, FOKKER

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# Lee Swee Meng

General Manager  
COMPOSITE TECHNOLOGY  
INTERNATIONAL



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CTIPL did factor in oil prices into the annual projection, but we discovered that the demand did not diminish. Companies such as Airbus Helicopters, Leonardo Helicopters and Bell Helicopter have described steady helicopter sales in the region.

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**Composite Technology International is a rotor blade repair specialist. Could you describe the main ways in which you serve the aerospace sector in Singapore?**

Composite Technology International (CTIPL) was established in 1984. We currently service more than 120 customers in 18 countries within the Asia-Pacific region. CTIPL is an authorized customer service facility of Airbus Helicopters, Bell Helicopter, Leonardo Helicopters and Sikorsky. Since 2012, our business has experienced an exponential growth and CTIPL has sourced 12-14 new clients per year. Though all of our repairs take place in Singapore, we continue to expand our customer base into new countries. We have also made some major renovations to expand our facilities in the Loyang Aviation Estate, near Changi Airport. There are 21 people operating out of this facility and we undergo an average throughput of 450 blades annually, providing a full range of specialized services for composite and metal helicopter rotor blades.

Our operations are strategically located in Singapore to act as a hub for the region and we are supported by a pool of dedicated technicians with in-depth know-how and professionalism. CTIPL initially worked with Airbus Helicopters and Bell Helicopter; Leonardo Helicopters and Sikorsky were included later. These OEM's repair approvals are confined to agreed territories, and that is the reason for establishing our presence only in Singapore.

**Given the global downturn of oil prices, some companies in the helicopter industry have faced challenges. Have you perceived a decreasing industry trend from the OEMs themselves?**

CTIPL did factor in oil prices into the annual projection, but we discovered that the demand did not diminish. Companies such as Airbus Helicopters, Leonardo Helicopters and Bell Helicopter have described steady helicopter sales in the region.

**The aerospace industry in general has observed an increase in the use of composite materials for manufacturing. Which would you say is the future trend for rotor blades in this realm?**

CTIPL has seen tremendous growth in blades that are made out of composite materials. In the past, there used to be only metallic rotor blades but today we work more on composite blades. We do not perceive a strong difference between the materials relating to repair processes though composite blades, which have a much longer finite life and are more repairable as compared to metallic blades, provide us more repair opportunities.

**What percentage of your operations stem from military and defense as opposed to commercial aviation in Singapore?**

CTIPL's business comprises roughly 40% military and defense, and 60% commercial aviation. We work with international military/defense customers in countries such as the Philippines, Thailand, Indonesia, etc. We have six Approved Maintenance Organisation (AMO) approvals from relevant civil aviation authorities in this region and Europe. We received the Singapore Aerospace Award for Singapore Aerospace Industry Excellence, Platinum, in 2014. This is a strong accomplishment for our company and it speaks well of our capability and capacity in maintaining the highest standards

of business, safety and quality.

**What are the advantages of operating as a smaller company while servicing multi-nationals?**

As a smaller company, CTIPL is much easier to manage and control. Our services remain focused on our core business of helicopter rotor blade repairs. Many larger companies opt to diversify and operate with a large workforce, but I believe our strength lies on this niche capability. We experience low manpower turnover rate given the loyalty of our employees, which are all local. However, sourcing skilled labor is challenging. In Singapore, younger generations nowadays seem to loathe manual work that may get their hands dirtied, and there is an overarching feeling that starting from the ground up is not worthwhile. Recruitment can become a challenge.

**What is your outlook for CTIPL for the next 3-5 years?**

Regardless whether there is a slower growth in the market, we will inevitably reach a saturation point where our growth will slow down or plateau. We will have to be nimble and possess a proactive attitude to the industry to ensure we are prepared to face challenges whenever they approach. CTIPL will continue to operate as a highly reputable company to partner with. Singapore will capitalize the rapid growth in aviation activities in Asia. This country is a key global player in aerospace MRO with an excellent seaport, airport and infrastructure, and I would therefore encourage helicopter companies and manufacturers to join into this ecosystem and get in touch with us for business or partnership.

# The Implementation of Industry 4.0 and New Technologies

By Elisa L. Iannacone and Alice Pascoletti

Automation, Internet of Things (IoT), additive manufacturing and all processes that assist Singapore in addressing rising costs and labor shortages are paramount to the successful development of the country's aerospace industry. Despite the industry's investments in new training facilities to grow the number of graduates in the market, such as Haite Group's S\$95 million (US\$67 million) training facility with simulators, the speed at which skilled labor is needed in the region is greater than the country's capacity to supply trained workers at the moment. The EDB and A\*STAR are investing heavily on technology innovation processes. "We are currently looking at the application of robotics, automation, data analytics and additive manufacturing. In the nearer term, we are focused on innovations and technology that would make Singapore more competitive," said Tan Kong Hwee, director, transport engineering, EDB.

Though Industry 4.0 processes will aid the industry at the moment, whether this can feasibly act as a permanent solution remains uncertain. The first concern that must be addressed is the speed at which the transition into automation can take place within the industry. "In my opinion, it will take an incredible amount of alignment with the manufacturers and regulators to implement robotics and automation successfully into aerospace operations," said John Riggir, vice president and general manager, JET Aviation.

Though the company has implemented 3D scanning to reproduce aircraft interiors and utilize cutting-edge 3D engineering and manufacturing processes to cut honeycomb panels with laser and waterjets, the real advantages will be felt in terms of aircraft assembly, where skilled labor will be replaced by automation. The company is not focused on Artificial Intelligence (AI) at the moment, but be-

lieves that no regulator will be allocating permits and approvals within that realm anytime soon.

Although the EDB is pushing for robotics and AI developments within the aerospace field, some are questioning the capacity that disruptive technologies will have to truly aid their operations, especially given the high-levels of investment required to implement them. "Using automation in the aerospace aftermarket environment would require a major investment whereby I reckon not many SMEs would find it economically viable [...] The challenge is not how to get it automated, but rather, what is the payback?" said Philip Sung, director, sales and operations, Esterline. Nonetheless, the opportunities to be found within the repair value stream are to be explored. In order for automation to become more common, it has to prove that it can provide greater advantages and solutions for Singapore than the sourcing of skilled-labor within the SEA region.

The reasoning behind companies' decisions to seek out disruptive technologies is quite varied. In the case of Accuron, it is the drive to take precision engineering up the value chain with own designs, which require more cost-efficiencies. "We will always watch out for disruptive technologies and techniques, such as additive manufacturing. It may take a while for this to truly become prevalent in the aerospace industry, but I think that change will take place swiftly. We will also see people making use of Industry 4.0, IoT, or simply automation to improve the manu-



**COMMITMENT TO EXCELLENCE**

Established in 1984, CTIPL has provided niche helicopter rotor blade MRO services to the aviation industry. Here at CTIPL, we provide multi-manufacturer rotor blade repair and refurbishment to our more than 120-strong clientele base across Asia and Oceania.

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We have planned to introduce robotic welding in our flexible manufacturing cell within the next year. Despite the current market sentiments and inherent risk of failure, we are compelled to think long-term and instead of making decisions based solely on an immediate-term cost-benefit analysis. We see this as the way forward because of the shortage of skilled Singaporean welders and machinists will be a perennial issue. In order to compete globally we need to be courageous in finding alternative ways to address these challenges.

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**Lim Hee Joo, Executive Director, WAH SON ENGINEERING**

sensor technologies. The UK-based industry giant has already implemented the use of Big Data within its civil aerospace TotalCare service offering. “We are pioneering the technology behind autonomous vessels, utilizing IoT, which can be remotely controlled,” said Bicky Bhangu, director Singapore, Rolls-Royce.

Despite the challenges in pioneering new technologies, Rolls-Royce is a firm believer that implementing Industry 4.0 processes will add value to their operations in the future. “One of the major challenges in the digital field is creating adequate algorithms that can integrate the whole value chain,” added Bicky Bhangu.

The company has positioned itself as a systems integrator that is able to partner with clients to provide them with predictive maintenance. New simulators and AI are being developed in Singapore for the aerospace industry primarily for the military and defense industries, which need to focus on crisis-management within airports. Asia Technical Service’s partners, MASA, are developing an AI system alongside the French army, to train high-level military officials. “This constructive simulation software, with its AI, is being used within the Singapore Ministry of Defense’s think tank,” said Patrick Garez, managing director, Asia Technical Services.

Although these new Serious Game type technologies are still foreign to the market, they are gradually becoming more common. “I believe they will take hold of the industry and evolve incredibly rapidly,” he added.

The company is creating a strategy for a 70% staff-reduction within the army based on these simulation technologies. Though most 3D and VR technologies tend to remain within the commercial segment of OEMs, the training possibilities are being explored. MROs will require a longer process of certification and approvals in order to be able to implement such interactive training materials within their operations. The implementation of mobility, digitization and big data represent a change in the way that companies relate to customers, employees and their own processes. Various companies, such as Lufthansa Systems, are positioned to assist clients by implementing IT solutions to optimize their service offering through data analytics.

Accessing and analyzing the large amounts of data that is collected by airlines can help them improve and even personalize

facturing process,” said Tan Kai Hoe, president and chief executive officer, Accuron.

Wah Son Engineering has decided to introduce robotic welding in their flexible manufacturing cell within a year’s time. “Despite the current market sentiments and inherent risk of failure, we are compelled to think long-term instead of making decisions based solely on an immediate-term cost-benefit analysis. We see this as the way forward because of the shortage of skilled Singaporean welders and machinists will be a perennial issue,” said Lim Hee Joo, executive director, Wah Son Engineering.

Rolls-Royce has also implemented a full range of processes within the digital sector, from software and connectivity, to

## Tan Kai Hoe

President and CEO  
**ACCURON TECHNOLOGIES**



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There is no choice for precision engineering but to go up the value chain. To own the designs is key to the segment’s continued growth. We will develop new techniques and methods for making parts more cost-effectively and efficiently.

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**Could you describe your transition from having worked as Chief Executive in SPRING to becoming the CEO for Accuron Technologies?**

I joined Accuron Technologies a year and a half ago. Before this, I spent 25 years serving in the navy and then working in SPRING Singapore, eventually as chief executive. Given my previous experience in SPRING where we were facilitating the growth of Singapore enterprises, I wanted to experience the chance of building up and growing a company directly for myself.

**Singapore Aerospace Manufacturing (SAM) is a subsidiary of Accuron Technologies. Could you describe the relationship between Accuron and SAM in terms of aerospace?**

Singapore Aerospace Manufacturing (SAM) was incorporated in 1981. A few other companies were formed in the 1990s, including Dornier MedTech and Advanced Material Technologies. In 1999 there was a decision to group these companies under the Singapore Technologies Precision Engineering (STPE) umbrella. STPE later changed its name, finally becoming Accuron Technologies in 2005. SAM has also acquired other companies including German-based Sitec Aerospace and KLSE-listed SAM Engineering and Equipment.

Today, Accuron has two main business groups – one is the SAM group and the other is the MedTech group. Accuron’s revenue stems from SAM (70%) and Medtech (30%). In turn, about 70% of SAM’s total business is aerospace and the remaining 30% is devoted to industrial equipment and automation. Accuron

is both a contract manufacturer as well as an OEM that designs and produces certain components such as linear actuators and valves. Some of our current operations are undertaken by subsidiaries which were acquired in the past decade. We continue to acquire companies to expand our service offering, capacity and capabilities.

**With a presence in Singapore, Malaysia, Thailand, China and Germany, does Accuron Technologies have the intention to continue growing internationally?**

Yes, Accuron Technologies will continue to pursue its growth internationally. The main driver for our business is not so much labor costs, but rather access to the talent pool. Certainly, labor cost is something we have to manage and there is a tendency to look for alternate locations to manufacture more cost-efficiently. But we are mainly looking for locations that are not too far from us geographically and carry the talent pool to serve our needs.

We will also continue to seek new partnerships and collaborations to jointly invest in growth. Aerospace is a capital-intensive area, but we are willing to take a long-term view and invest the required capital to drive new growth.

**Which are the future trends and potential of precision engineering in Singapore and the region?**

There is no choice for precision engineering but to go up the value chain. To own the designs is key to the segment’s continued growth. We will develop new techniques and methods for making parts more cost-effectively and efficiently. Singapore is well positioned to manufacture

complex parts, which will give the country an added value. International competition will always be present at multiple levels, such as in China, Japan and Korea, which all have very sophisticated technologies. The goal is to continue to spearhead and be at the forefront of the precision engineering industry.

We will always watch out for disruptive technologies and techniques, such as additive manufacturing. It may take a while for this to truly become prevalent in the aerospace industry, but I think that change will take place swiftly. We will also see people making use of Industry 4.0, IoT, or simply automation to improve the manufacturing process.

**Based on your experience, could you describe the aerospace SME market’s future trends and where you see the industry going in Singapore and SEA in upcoming years?**

I think Singapore’s reputation for consistency, good quality and on-time delivery will put our Aerospace companies in good stead. The governmental efforts to support the aerospace industry through entities such as the EDB, A\*STAR and SPRING are helping the SME and micro-enterprise segments to continually grow and reach their targets much faster than they would if they were operating alone.

Young technology companies which offer interesting solutions for the aerospace industry are also emerging. This push for new innovations and technologies represents a potential area of growth for the country and aids it in pursuing its goal of becoming a leading cutting-edge technology world center.





Image: Rolls-Royce

their services for passengers. IoT sensors can be used to collect data regarding temperature, engine performance and even passenger in-flight entertainment choices. According to Lufthansa Systems: “In the airline-passenger relationship, process digitization and data usage are the key to differentiating oneself from the competition by offering personalized products and services.”

Despite Singapore’s clear footprint within the realm of future technologies, the rapid growth experienced in the surrounding emerging markets is also placing pressure on the country to continue innovating and improving. “As countries in the region develop and modernize, the gap that currently makes Singapore stand out from the rest will certainly narrow. This means that continuous innovation is indispensable,” said Christophe Potocki, general manager, sales, ATR.

The continuous pursuit to spearhead the development of smart technologies and Big Data processes remains at the heart of many Singapore operations.

UAVs are also an area of high interest for the Singapore aerospace industry, and the EDB aims to explore all the ways in which research institutions can partner with companies working in the field. The Skyways Experimentation Project will be running UAS trials in Singapore to develop the necessary aerial avenues for parcel deliveries within the country’s urban landscape. The project will run in two phases, the first will be the creation of a network of parcel stations within NUS campus in order to deliver urgent documents. The second will involve delivering objects such as electronic parts and medicines. The “Civil Aviation Authority of Singapore (CAAS) has signed an MoU with Airbus to experiment with delivery drones,” said Tan Kong Hwee.

The EDB, A\*STAR and the CAAS, along with Universities such as NTU, are undertaking the incredibly challenging feat of experimenting with UAVs to determine the extent to which these new technologies can aid the increasingly demanding market in the country. With the level of investment and know-how in the country, Singapore is well positioned to lead the way and determine the ways in which the world can implement new technologies to assist the operations of the aerospace industry. —



## Ryuta Suzuki

General Manager  
MITSUBISHI ELECTRIC ASIA

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Singapore’s space business core focus is Earth observation, and they are looking for smaller and more compact spacecraft for operations, which is an overarching trend.

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### Could you describe your goals for Mitsubishi Electric Asia?

Mitsubishi Electric Asia is a representative office for our space business that meets with customers and assists our headquarters in Japan to negotiate on satellite deals. We promote our products via conventions and conferences. Mitsubishi Electric as a whole considers the aerospace sector as one of the growing sectors within our business. Within this, we have an important focus on the space sector, where we are looking to continue growing through on-going investment and product lines. Mitsubishi Elevators is another division within the company, and they specialize in escalators and elevators exclusively.

Mitsubishi Electric has a satellite standard platform called DS2000, which has been implemented on many civil and commercial satellites. We are planning a development program to enhance our spacecraft capabilities with the aim to double our capacity by 2021. HTS (high-throughput satellite) is becoming increasingly important to provide more throughputs to the end users. Powerful and compact satellites are necessary due to higher power demands by the HTS payloads to put many beams on the ground. In 3-5 years we hope to be providing this powerful HTS satellite to all of our satellite customers by completing this development. Though the satellite clients in Singapore are few, we expect demand to increase in the Asia Pacific region in the longer term. Singapore is very conveniently located to travel to other countries in the region. We take advantage of this easy-access to expand our business. Our vision is not just for Singapore, but for Asia Pacific and India.

### In which way is Mitsubishi Electric involved with Singapore’s space sector and could you highlight your service offering within it?

Mitsubishi Electric’s space department in Singapore started operations about 10 years ago to promote our space products mainly within the SEA and AP regions. Singapore has a somewhat limited commercial space business capacity, but is very active in the field of observation satellites and nano-satellites. We are also

actively involved in Earth observation, satellite positioning, communication satellites, and even explorers to the Moon or Mars. Singapore’s space business core focus is Earth observation, and they are looking for smaller and more compact spacecraft for operations, which is an overarching trend.

Many companies are launching small and high-performance Earth observation satellites. Since Mitsubishi Electric also has many experiences in Earth observation spacecraft, we may be able to provide some space units and components for spacecraft being manufactured at the universities or by a manufacturer.

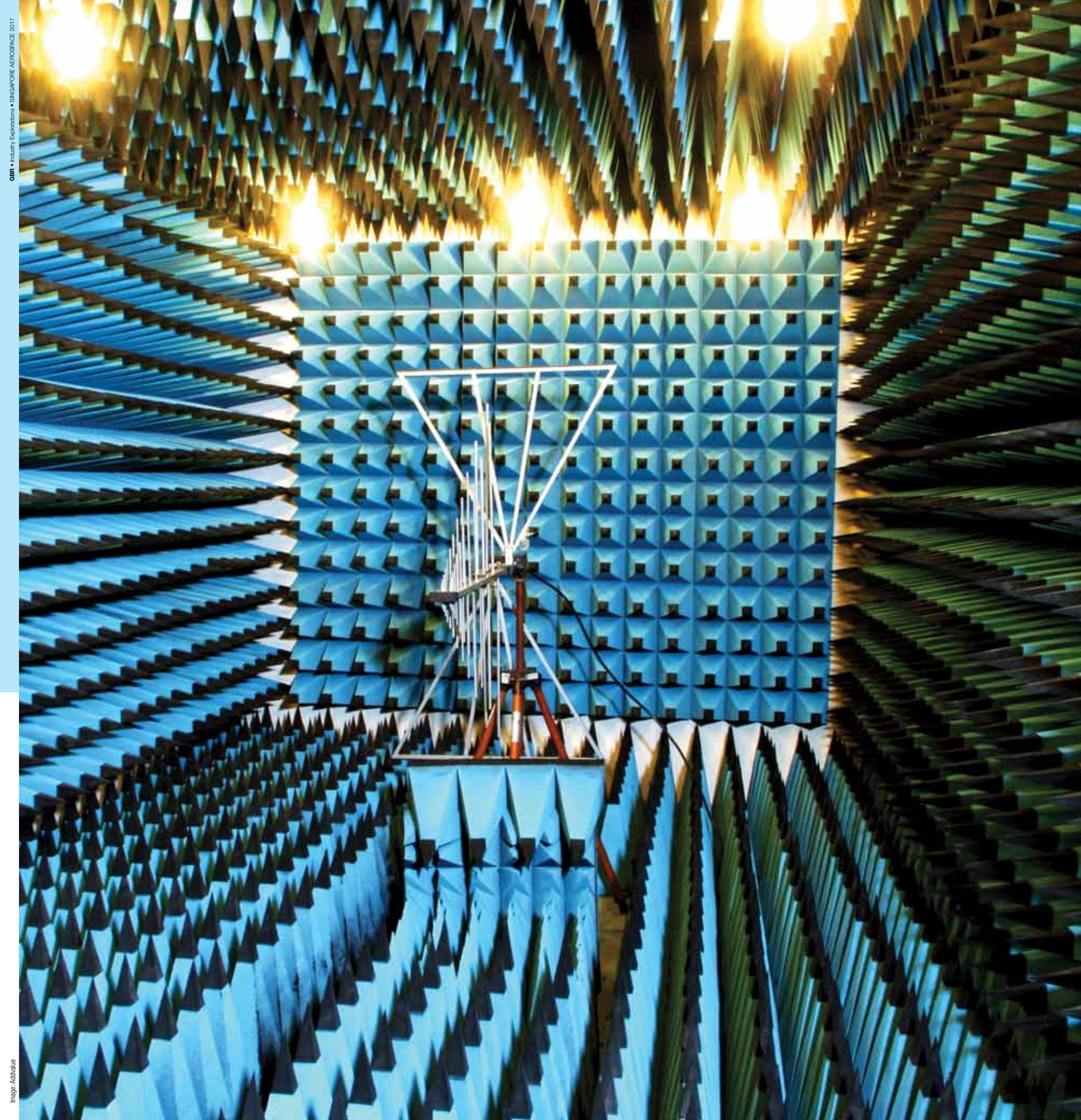
### What is the importance of implementing Industry 4.0 processes in the manufacturing space business?

The goal of automation within the space business is to revolutionize the way in which we manufacture satellites, because they have to be produced cheaply. It is becoming increasingly important to automate some of the processes that are currently undertaken manually. Though this evolution is not taking place at a global scale yet, I believe that it will inevitably happen very soon. Additive manufacturing will become much more focused than it is presently. The revolution for spacecraft manufacturing processes has already started with the introduction of 3D printers. If this is implemented in a more aggressive way, perhaps in five to 10 years we may see more complicated and compact spacecraft being manufactured by 3D printers.

### The Singapore Government is encouraging businesses to develop their own IP products. Could you describe how Mitsubishi Electric applies this to the space sector?

In terms of the space business, Mitsubishi Electric produces everything in-house. We have our own engineers, product line, manufacturing facilities and test facilities. Nonetheless, it would be important to create an engineering center that could interact directly with the customer to understand their satellite needs, and develop draft plans that reflect this. We could then relay the information back to the factory to build the products.





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Image: Adhvaite

# SPACE



"The Singapore Space industry is well positioned through its commercial and pragmatic approach, developing niche capabilities that augment the future digital economy."

Jonathan Hung, President,  
Singapore Space and Technology Association



# Introduction to Space

By Elisa L. Iannacone and Alice Pascoletti

Though it is mostly known for commercial aviation and MRO, Singapore has an awakening space industry that is looking to develop key competences to become an industry leader within a niche part of the market. With 30 active companies and a workforce of over 1,000 professionals, the Singapore space industry has grown dramatically since 2011, when only 150 researchers were covering the sector. “Over the next five years, the industry will continue to employ an additional 300 professionals across the entire satellite value chain, from engineering to service provision,” said Beh Kian Teik, executive director, Office for Space Technology and Industry (OSTIn), EDB.

Singapore’s closeness to the Equator makes it a strong location for satellite testing to take place. “We can receive very high-coverage with only one satellite given that each orbital period lasts approximately 1.5 hours. To achieve the same results further north, we would need to deploy a constellation of satellites,” said Dr. Erick Lansard, vice president, technical and space development, Thales Solutions Asia.

Since 2011, Singapore has launched 11 small satellites. Leading satellite operators, such as Inmarsat, Intelsat and Eutelsat have started basing operations in the country, which is also pushing the Singapore space industry to comply with the highest industry standards and develop cutting-edge products.

With an increased focus on micro- and nano-satellites, Singapore seeks to develop New Space Engineering technologies through advanced R&D to improve satellite performance. Six small locally built satellites were launched by Singapore in December 2015, showcasing the country’s engineering capabilities. The EDB created the Office for Space Technology and Industry (OSTIn) in 2013 to support the growth of the industry and further develop New Space opportunities, as well as New Space applications and services in

the region. “We encourage public-private collaborations as part of our effort to translate research into commercial products and services,” said Beh Kian Teik.

Creating a rich environment for the space industry, where companies can leverage on Singapore’s extensive engineering know-how and R&D, is in the making. With two main focus areas, the design and manufacture of small Smart satellites and the advanced application of satellites, Singapore may not have a large quantity of products

at the moment, but it certainly has a long-term roadmap of space development in the pipeline. Companies like ST Electronics and smaller SMEs have successfully launched their own satellites and are paving the road for Singapore’s international space recognition. Space-based equipment manufacturers developing satellite components, sensor systems and materials can seek collaborations with Singapore’s research entities, such as the Data Storage Institute (DSI) and Institute of Microelectronics (IME).

Beyond commercial satellite integration, companies can turn to Singapore to develop satellites and new technologies with the universities. Both NTU and NUS run development programs exploring formation flying, altitude and propulsion subsystems, among several others, for micro-

and nano-satellites. “From the university research satellite standpoint, we will probably see between four to five satellites designed, built and attempted to be launched every two to three years,” said Jonathan Hung, president, Singapore Space and Technology Association.

Developing larger payload capacity for satellites is a core focus for new satellites being built in the country. On-board propulsion is another aspect that has started appearing on nano-satellites, making way for formation flying. “This is a very important and recent development, and it is a key to enabling technology that Singapore is positioned to develop,” said Dr. Erick Lansard.

Singapore is developing international partnerships within the space industry through OSTIn. Companies and space agencies

keen to develop space technologies, especially within the field of satellites, can come to Singapore and make use of its extensive R&D strengths. Previously having signed a collaboration agreement with the French Space Agency, CNES, the EDB also signed a MoU with major satellite operator SES to explore next-generation satellite technologies, such as the design, prototyping and production of technologies for satellite mobility applications in the aeronautical, automotive and maritime sectors.

NTU has established a 24/7 mission control center for monitoring the satellites they have in space. The VELOX-CI has been in space since December 2015 and is mainly used for monitoring climate through GPS signals that generate data on items such as pressure, humidity and temperature. The VELOX-II proved that

nano-satellites can be controlled to communicate with GEO satellites to allow for direct internet links to the satellite without the need for a ground station. With a total of seven satellites in space, NTU is leading the way in terms of data monitoring and new technologies that can be implemented for space monitoring activities.

The first Singapore satellite launched from the International Space Station took place successfully on January 16th, 2017 as a collaboration between NTU and Kyutech. The AOBA VELOX-III contains a micro-propulsion system that is capable of double the satellite flight time in space. This technology tester will allow for more elaborate missions in the future. Another joint satellite is scheduled to be launched in 2018. With the technologies demonstrated by the two satellites, NTU and Kyutech are aiming to jointly develop a future lunar mission.

Despite Singapore’s major space achievements, the major challenge experienced by the space sector is convincing the world that the necessary capacities and capabilities for a successful space industry are present in the country. Although Singapore does not yet have a Space Agency, players in the sector are aiming to continue growing the right technologies to position the industry on a global playing field. Developing commercial space products is key to the long-term sustainable vision for the country. Companies looking to invest in space projects are encouraged to leverage Singapore’s advanced technological offering to launch their ideas more quickly and with a strong partner.

Companies looking to grow internationally can turn to Singapore as a launching pad into ASEAN countries, as well as the SEA and the Asia Pacific regions. To successfully commercialize satellite solutions, a collaborative environment that has the support of the government, the industry and the institutions is indispensable, which is exactly the kind of offering that Singapore can supply. Singapore also supplies the necessary financial backing as a tax-friendly environment to support companies looking to finance their projects with a base in the country. Though further government investment will be necessary to take the industry to the next level, the wheels have been set in motion to create a strong space industry that is capable of developing new technologies that will have a ripple effect across the globe.



Image: Addvalue



# Jonathan Hung

President  
SINGAPORE SPACE AND  
TECHNOLOGY ASSOCIATION



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Singapore is active in Earth observation, telecommunications and navigation services, as well as small satellite design and manufacturing.

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**Singapore does not have a dedicated Space agency. Could you describe the role that the Singapore Space and Technology Association plays?**

Although Singapore's aerospace output is strongly MRO based, we are home to a fairly established base of companies devoted to Space and telecommunications. The Singapore Space and Technology Association was founded to support the development of the Space industry through B2B growth initiatives. We provide support to the companies operating within this sector given that Singapore does not have a dedicated space agency.

Singapore is active in Earth observation, telecommunications and navigation services, as well as small satellite design and manufacturing. We support partnerships between all companies and organizations. At the moment we represent 30 corporate members, which are both local and international.

**What will the Singapore Space industry's core focus be over the medium term?**

Singapore has been making positive strides in satellite development, especially so over the last decade that saw successful launches of locally built satellites. The market is made-up of small satellite manufacturing, services and applications, satellite subsystems and technology advancements.

Singapore has two focus areas which we are aiming to further develop: the design and manufacture of small, "Smart" satellites, and the advanced applications of satellites. Most institutions have a roadmap of five to 10 years, and manufacturing a satellite typically takes two to four years. We might not see large numbers of satel-

lites going into Space on an annual basis due to our desire to get the basics and foundation right, but there is a pipeline and ready potential to steadily increase our output capacity. From the university research satellite standpoint, we will probably see between four to five satellites designed, built and launched every two to three years.

There are plans for our next range of satellites to allow for larger payload capacity. Due to the primarily commercial nature of our domestic space companies, there is a highly focused and deliberate approach to developing innovative, yet commercially sustainable programs. Homegrown Space companies such as ST Electronics and SMEs have grown and successfully launched their own satellites and payloads, proving the model works. They are leading the way in Singapore in terms of satellite development and continue to embrace global partnerships.

**What kind of services does Singapore offer in terms of Earth observation?**

Providing high-resolution, optical imagery on-demand is a strong market for Singapore. TeLEOS-1, ST Electronics's domestically built and recently launched satellite is positioned at a near equatorial orbit, differentiating itself over traditional polar orbiting satellites. This allows for higher revisit rates, and is highly useful for a wide range of commercial, research and security clientele that need good imagery on demand.

We are home to some of the best imagery processing capabilities in the region. For the past two decades, CRISP (the Centre for Remote Imaging, Sensing and Pro-

cessing), which is based at NUS, has been operating as a non-profit ground station, receiving and processing imagery from a wide range of remote sensing satellites. They are recognized domain experts and an integral component of our local Space ecosystem, providing dedicated ground station services to a global clientele.

**What future trends can we expect to see in the future for the Singapore Space industry?**

It is becoming increasingly important for governments to justify Space exploration in terms of social and economic returns. This means decreasing mission costs, increasing efficiency and mission life, and pursuing research and experiments that have potential to improve aspects of life on Earth. The Singapore Space industry is well positioned through its commercial and pragmatic approach, developing niche capabilities that augment the future digital economy. The SSTA continues to encourage our domestic space ecosystem to seek international, mutually beneficial partnerships, spur growth in the region, and perhaps be a regional hub for cutting edge Space innovation.

To achieve all of the above, we recognize the need to build a strong talent pool of budding Space engineers and scientists. The SSTA focuses heavily on Space education initiatives, drawing on local talent, and partnering global experts to build and sustain interest: an interest and culture among our youth to be highly passionate about science, be at the forefront of technology, and create a meaningful future for the global society. That, I believe, is at the heart of all of us within the Space community.

# Beh Kian Teik

Executive Director, Office for Space  
Technology and Industry (OSTIn)  
SINGAPORE ECONOMIC  
DEVELOPMENT BOARD (EDB)



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Singapore already has a small but vibrant satellite industry, with over 30 companies creating high value jobs for more than 1,000 professionals engaged in a wide range of activities.

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**Since when has the EDB supported Space operations in Singapore and what is your vision for the Singapore Space industry?**

The Singapore Economic Development Board established the Office for Space Technology and Industry (OSTIn) in 2013 to pursue "New Space" opportunities. Our initial efforts are focused on small satellite applications and technologies. This involves building up the small satellite capabilities of our public research institutions through competitive grant calls and small satellite missions. We encourage public-private collaborations as part of our effort to translate research into commercial products and services. OSTIn also supports companies that are interested in leveraging Singapore to innovate and develop "New Space" applications and services. Our long-term vision is therefore to create a vibrant Space ecosystem for Singapore, where companies can tap into our deep engineering and research capabilities to innovate and export "New Space" products and services.

**Could you provide a brief background of Singapore's space industry?**

Singapore already has a small but vibrant satellite industry, with over 30 companies creating high value jobs for more than 1,000 professionals engaged in a wide range of activities – from the design and manufacture of Space components, to the provision of satellite-based services. Since 2011, Singapore-based entities have launched 11 small satellites, and major satellite operators like SES, Inmarsat, Intelsat and Eutelsat, as well as startups such as Astroscale, Spire and Microspace all have significant presence in Singapore. Indeed,

Singapore's space industry has grown rapidly. From a base of 20 researchers in 2011, we now have a community of over 150 researchers working on satellites. Over the next five years, the industry will continue to employ an additional 300 professionals across the entire satellite value chain, from engineering to service provision.

**With an increased focus on micro- and nano- satellites in the country, what niche Space roles is Singapore trying to develop competencies in?**

We seek to develop a technology edge in New Space engineering, through investments in R&D which improve the miniaturization of components while simultaneously improving performance. As more small satellite constellations come online, we are also exploring building up capabilities that enable richer features and functionalities such as propulsion technology, constellation management algorithms, and more. In Dec 2015, six small satellites built by Singapore-based entities were launched into Space, a testament to Singapore's indigenous small satellite engineering capabilities. This positions Singapore well to capture the growth of the New Space economy, with the burgeoning of new product ideas and markets for satellite-enabled applications. With our strengths in electronics and ICT, we believe Singapore can play a substantial role in this new growth phase of the satellite industry. It will be an exciting time ahead.

**Is Singapore developing key international partnerships within the space industry? If so, with who and with which purpose?**

One of OSTIn's core missions is to forge collaborations between Singapore and the international space community on space initiatives. In 2015, EDB signed a Letter of Intent with French space agency CNES to explore possible areas of collaboration in satellite component development. In June 2016, EDB also signed a MoU with major satellite operator SES to explore next-generation satellite technologies, such as the design, prototyping and production of technologies for satellite mobility applications in the aeronautical, automotive and maritime sectors. Beyond these partnerships, EDB also looks forward to future engagements with members of the international space community for mutual growth and development.

**In which ways will developing Earth observation and telecommunications technologies aid the aerospace sector?**

The use of satellite data (e.g. satellite images) is well understood in the context of defense and military intelligence applications, so we will focus on the opportunities in the Satellite-enabled tracking technologies that can help pilots and ground station crew track the location of aircrafts which can help to raise early alerts in event of anomalies, and expedite search time in cases of missing aircraft. The data could also help airlines better plan their route and optimize fuel savings. We see satellite enabled telecommunications, especially in the form of High Throughput Satellites, as improving the overall inflight experience for passengers by providing seamless, high speed connectivity. Such developments could also open up opportunities for new applications in the airline industry.

# Satellite and Telecommunication Innovations

By Elisa L. Iannacone and Alice Pascoletti

As intelligent satellite based services expand, companies are realizing the importance of utilizing analytics to process Big Data for improved performances, as well as implementing IoT, and IDRS technologies. Remote sensing has become indispensable for disaster management, precision farming, climate change monitoring, urban planning and mineral exploration, as has satellite-based communication for the maritime and aerospace industries. Many R&D institutions are present in Singapore for companies to explore the multitude of possibilities for which satellite-based services and telecommunications can

improve their operations. Singapore's Centre for Remote Imaging, Sensing and Processing (CRISP) has the capacity to complete SAR, multi and hyper-spectral data analysis. The Institute for Infocomm Research (I2R) and the Institute of High Performance Computing (IHPC) are others exploring the many possibilities for sat-coms. Singapore is not lacking in telecommunications opportunities. Communications equipment manufacturers, such as Addvalue Technologies, are providing services to lead service providers that rely on satellite technologies. Multiple satellite operators

and communication service providers, such as SingTel, Thuraya and Intelsat have opted to base out of Singapore, leveraging on the country's well-established infocomms and aerospace industry. "We have reached a point where everybody is using navigational satellite technology, whether explicitly or not," said Christine Koh, market development director, Spacetime Technology. Sensors and Global Navigation Satellite System (GNSS) chip-sets and receivers are used for air navigation, cellphone GPS applications, photo geocoding and even social networking. The broad usage of these technologies also poses some risks for the security and defense realm, where important country targets or networks could be disclosed unwillingly. Companies and service providers are trying to find the necessary balance between advancing technology and protecting their clients. "The main consumers for these GNSS technologies are governments and large corporations that need Big Data for their decision making processes. Smaller SMEs are still not implementing these, but we will see that the trend will change rapidly in years to come," added Christine Koh.

Launched in October 2015 with the support of the EDB and GLAC (GNSS and LBS Association of China), Spacetime Technology's Singapore Centre of Excellence (CoE) was created as the first advanced incubator for GNSS and LBS in Asia. Its goal is to develop new technologies and innovate processes in order to generate new solutions for the industry. "With a strong focus on making operations easier for businesses and having an impact on people's daily lives, Spacetime Technology has the aim to launch technologies that can revolution the market," said Ping Teck Huat, CEO, Spacetime Technology. IoT was implemented for M2M (Machine to Machine) applications nearly eight years ago for the oil and gas sector and technology has evolved significantly since then. "Addvalue is active in the IoT arena as the ubiquity and reliability of satellite communications are essential to complement the terrestrial communications to fulfill the insatiable desires of connectivity in any industry," said Tan Khai Pang, chief technology and operating officer, Addvalue Technologies.

Earth observation and remote-sensing applications are now amply used by lead global players. High-resolution optical services have become a strong offering within the Singapore market. Singapore's first commercial Earth observation satellite, ST Electronics's domestically built TeLEOS-1, was launched from India on December 16th, 2015. Five more home grown satellites were launched alongside it. The TeLEOS-1 is near an equatorial orbit and allows for higher re-visit rates as well as providing services for research institutions and security companies. "Many new and impactful applications could be demonstrated in/from Singapore for both military and civilian needs, for instance in the fields of Earth observation, meteorology, navigation, data collect, telecommunications etc., leveraging on Thales excellence in optical and microwave satellite payloads, platforms and systems," said Dr. Erick Lansard, vice-president for technical and space development, Thales.

The Centre for Remote Imaging, Sensing and Processing (CRISP), based out of NUS, has been processing satellite images for the last 20 years as a non-profit ground station. Their imagery can be used across the value chain, but when paired with data-

analysis, these technologies can even help aircraft save on fuel costs and strategize their routes better. The center is researching Synthetic Aperture Radar (SAR), as well as multi- and hyper- spectral data analysis. High throughput satellites (HTS), a type of communication satellites that provide over twice the total throughput of a traditional FSS satellite, are being used to explore new opportunities and applications within the aerospace industry. Addvalue has also been exploring Inter-Satellite Data Relay Systems (IDRS), which are a means to addressing the 'on-demand' obstacle that LEO satellites were unable to overcome on their own. Addvalue launched an IDRS terminal aboard the VELOX II, supplying a two-way IP based

data service for LEO satellite operations, connecting them to higher-orbit GEO satellites, allowing for 24/7 on-demand results. The Addvalue IDRS services aim to be commercialized no later than the year 2020.

Beyond space exploration, Singapore has been involved in the development of an European Spaceplane through EADS Astrium, to make commercial sub-orbital flights possible. The aircraft is being developed by Airbus and aims to carry four passengers up to 100 Km above sea-level. OSTIn remains keen on attracting companies around the globe that intend to innovate and develop new technologies to position Singapore as an advanced-technology hub in the region and the world. —

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The goal of automation within the space business is to revolutionize the way in which we manufacture satellites, because they have to be produced cheaply. It is becoming increasingly important to automate some of the processes that are currently undertaken manually. Though this evolution is not taking place at a global scale yet, I believe that it will inevitably happen very soon. Additive manufacturing will become much more focused than it is presently. The revolution for spacecraft manufacturing processes has already started with the introduction of 3D printers. If this is implemented in a more aggressive way, perhaps in five to 10 years we may see more complicated and compact spacecraft being manufactured by 3D printers.”

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**Ryuta Suzuki, General Manager, MITSUBISHI ELECTRIC ASIA**

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It is always the commercialization of technologies that spurs more activities in the industry, which is why there is a strong push to try to commercialize nano-satellites. The commercial nano-satellite market is venturing for a breakthrough in business model.

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**Lim Wee Seng, Executive Director, School of Electrical and Electronic Engineering, NANYANG TECHNOLOGICAL UNIVERSITY**

“

Singapore is a solid location to test satellite technologies because it is located close to the equator, which allows for higher performance results. We can receive very high-coverage with only one satellite given that each orbital period lasts approximately 1.5 hours. To achieve the same results further north, we would need to deploy a constellation of satellites.

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**Dr. Erick Lansard, Vice-President for Technical and Space Development, THALES**





# Dr. Colin Chan and Tan Khai Pang

CEO and Chief Technology & Operating Officer  
ADDVALUE TECHNOLOGIES



**Could you give us some background information about Addvalue Technologies and its relevance to the aerospace industry in Singapore?**

**Colin Chan:** Addvalue was incorporated in 1994 to provide design services targeting the consumer electronics industry. In 1999, we expanded our market focus to the satellite industry and designed a digital satellite receiver for Sirius Satellite Radio. The company was listed on the Main Board of the Singapore Stock Exchange in the year 2000. Two years later, we made a major breakthrough into the satellite communications industry by procuring a significant contract to design a portable satellite terminal for Inmarsat. In 2006, we successfully launched our first mobile satellite communications product. Since then, Addvalue has effectively morphed into an entity which focuses only on the satellite and digital wireless communications market. To date, we have developed and commercially launched a full array of satellite communications terminals for land and maritime applications. In 2013, with the financing grant provided by the Singapore Government, Addvalue embarked on an ambitious project to conduct a proof-of-concept for an innovative inter-satellite data relay system (IDRS). The innovation will enable real time on demand communications with any Low Earth Orbit (LEO) satellite - a challenge faced by all LEO satellite operators today. Addvalue launched its Velox-II LEO satellite in December 2015 and successfully validated the proof-of-concept after more than a year of continuous testing. Addvalue shall further develop this technology and aim to commercialize the Addvalue IDRS services no later than 2020.

Our one-stop-shop product development capabilities and our core competency in sophisticated satellite communications technologies stand us out as a unique, innovative company in the world of satellite communications. We have also been providing sophisticated design services related to digital communication technologies for Singapore government-linked companies and organizations that are involved in aerospace applications. We hope to forge partnership with commercial companies in the aerospace industry.

**What opportunities does Addvalue have in China and the ASEAN region, as they are among the highest growth markets in the world?**

**Colin Chan:** We already have a wholly-owned subsidiary operating in China to help us identify and develop partnerships to tap into the immense market potential for satellite communications. While we have garnered strong market shares in the Chinese fishing vessel market, we are also cultivating opportunities in the general aviation market and the LEO satellite industry in China. Through partnerships, with integrators and resellers in the region, Addvalue has also been making headway into the ASEAN market, particularly in the Philippines, Vietnam, Indonesia and Malaysia, tapping into opportunities from governmental and enterprise projects, ranging from fishing management and environmental surveillance to smart grid, and smart cities connectivity. Furthermore and synergistically, the "One Belt, One Road" initiative promulgated by China will have a direct impact on accel-

erating many mega cross-border projects in the ASEAN region. We are ready to tap into such opportunities as our proven satellite and digital communications technologies and our knowledge in the region place us in good stead to partner with the China-based companies for the joint development of relevant products and services.

**Talk is rife about the Internet of Things (IoT) these days and there are great expectations for market growth through it. What is Addvalue's plan on this front?**

**Khai Pang:** Addvalue offered a few satellite communication products for Machine-to-Machine or M2M applications in the oil and gas and energy industries almost eight years ago. These M2M applications are akin to a kind of IoT solution that connects machines end to end via a satellite communications network. As the IoT enabling technologies continue to evolve, new applications will fuel the need for connectivity with anything, at anytime and anywhere. Addvalue is active in the IoT arena as the ubiquity and reliability of satellite communications are essential to complement the terrestrial communications to fulfill the insatiable desires of connectivity in any industry. Addvalue is working diligently to deliver satcom-based backhaul platforms that aggregate data from or disseminate data to a multitude of IoT nodes over a satellite network. One of the key IoT applications lies within a very wide area of remote sensing, and, in this regard, developing product technologies that allow large numbers of small sensors to have direct satellite access shall also be a core part of the product development strategy for Addvalue over the next two years.

# Solving an Age-old Problem that Vexes All Commercial Low Earth Orbit Satellites

By Tan Khai Pang, Chief Technology and Operating Officer, Addvalue Technologies

Since 2012, a key strategic move has been to develop a communications service to improve the operational efficiency of the expanding Low Earth Orbit (LEO) satellite based business. With its IDRS service, Addvalue plans to participate in this market, one that is projected to grow rapidly in the years to come.

Since the beginning of the Space age, virtually all non-synchronous satellites have operated with very limited non-real time communications support. Only the most important missions, such as manned launches and some US military satellites, are supported by 24/7 on demand data links. LEO satellites typically circle the Earth in less than 130 minutes and appear to move very swiftly to an observer on the ground. Currently the vast majority of LEO satellite missions are supported by networks of a small number of ground Earth stations distributed around the globe. Due to the limited number of Earth stations and the speed of the LEO satellites, these ground Earth stations can only provide intermittent communications services. To date, a typical LEO satellite is supported by from one to 10 minute long communications sessions, or passes, a day. Thus communications with a LEO satellite are currently unavailable for long periods of time. Furthermore, this limited availability is rigidly set in advance by the characteristics of the LEO orbit and the location of the supporting Earth stations.

This imposes limitations on how LEO satellite operations can be effectively and efficiently conducted. For instance, any anomaly on board the LEO satellite cannot immediately be reported to the satellite operator for diagnosis and quick resolution.

This delay in restoration of LEO satellite service can have significant economic impact. Real-time mission tasking is currently not possible since the LEO satellite operator must wait for the next available scheduled 'fly-over-Earth-station' session. With IDRS, LEO satellite operators can rapidly respond to data collection opportunities that would otherwise be missed. Applications that need longer sessions than the 'fly-over-Earth-station' time slot are not possible under the current scheme of rigid operations. There has been an increase in the use of more than one LEO satellite configured in a constellation for more sophisticated missions. The need for more real-time communications among these LEO satellites operating in a coordinated manner is crucial for such operations. Last, but not least, with IDRS the cost and duration of the commissioning period for new LEO satellites is greatly reduced.

What Addvalue has tested is the technical feasibility of leveraging a commercially available Geosynchronous Earth Orbit (GEO) satellite constellation system as a means to relay data to and from an orbiting LEO satellite so as to provide on-demand, near real-time data link services. Historically, Addvalue has been involved in the development of sophisticated mobile satellite communication terminals compatible with the Inmarsat I4 constellation BGAN network since 2004 - before the launch of the Inmarsat I4 constellation itself. Building upon these many years of experience, and with a view to expand its business beyond traditional Earth-bound markets, Addvalue began in 2012 to explore the feasibility of developing a termi-

nal suitable for deployment on small LEO satellites. The aim being to provide economical low latency, on-demand data communications known as Inter-Satellite Data Relay System ("IDRS") services to support LEO satellite operations. The Addvalue IDRS service will operate via the highly reliable Inmarsat I4 constellation and its BGAN network and be made available to LEO satellite operators across the globe.

Supported through a grant provided by the Office for Space Technology and Industry (OSTIn) of the Singapore Economic Development Board (EDB), Addvalue developed its first space-resilient communications terminal. An intermediate outcome of this endeavor is the realization of the Velox-II project, which involves a nano-size LEO satellite that carries the Addvalue communication payload for conducting the IDRS technical trial over the Inmarsat BGAN network. Developed in collaboration between Addvalue and Nanyang Technological University (NTU), the Velox-II was launched on 16 December 2015 and has been undergoing over a year of in-orbit tests. These tests have fully demonstrated the technical feasibility of Addvalue IDRS operation over the Inmarsat BGAN network.

The Velox-II's IDRS payload fits into a 2-U physical size and weighs less than 2kg. The Addvalue IDRS terminal will be a good fit for LEO satellites of down to nano-scale (100Kg or lighter). Capable of supporting data rates in excess of 100 Kb/s, the Addvalue IDRS solution is capable of providing on-demand 24/7 data connection services and mid-size data transfer. This is certainly a game changer in the existing way most commercial LEO satellites are operating their telemetry and command communications. By eliminating the in-sight-of-an-Earth-station limitation and providing an on-demand real-time communications link to LEO satellites, Addvalue hopes to provide a reliable platform for new market opportunities for LEO satellite operators in the foreseeable future.

The in-orbit testing of the Addvalue's IDRS terminal on Velox-II will continue to provide valuable test data for our engineers to analyze and improve the design for commercial purposes. Concurrently, Addvalue is in discussion with several leading industrial players in the LEO satellite industry to launch commercial IDRS service no later than 2020. —





## Dr. Erick Lansard

Vice-President for Technical and Space Development  
THALES

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We have also created the first regional Thales Innovation Hub in Singapore, where, alongside our main customers and end-users, we create new disruptive solutions together.

”

### Could you highlight a few of the partnerships and projects that Thales has developed for the Singapore space sector?

Singapore has a strong interest in small satellites (under 150-200 Kg). In support of that, Thales in Singapore has created a Space Centre of Excellence for Research and Technology (R&T) as well as developed a partnership with the Nanyang Technological University (NTU), which has been the frontrunner for satellite research amongst Singapore's academic institutions. We have created a joint laboratory named S4TIN (Smart Small Satellite Systems – Thales in NTU) where we develop new concepts and new technologies, leveraging on CINTRA, a joint lab between NTU, CNRS and Thales, that is focusing on nano-electronics and nano-photonics.

NTU is a strong partner for small satellite platforms and skill-set development, while Thales is focusing on the missions relevant for small satellites, though we remain interested in larger satellites and stratospheric platforms. We are exploring all of these at our corporate R&T center in Singapore, one of the five in the world, from the development of piggy-back payloads, to large satellites and telecommunications. We have also created the first regional Thales Innovation Hub in Singapore, where, alongside our main customers and end-users, we create new disruptive solutions together.

The target is not only to fly prototypes, but also to develop new industrial systems that could be manufactured locally in partnership with local actors, and new applications and services. Naturally, the intention is to address the global market, starting with the equatorial belt region. Beyond our collaboration with the Singapore Ministry of Defense, we are also exploring new partnerships with local partners for civilian missions.

### How important are the areas of research, development and technology for Thales?

Out of a total pool of 62,000 employees worldwide, Thales Group has one-third of these employees working on engineering research and technology activities. We invest 20% of our revenues into research and development and deeply believe that technology can bring great value to our operations. Given our strong technologi-

cal backing, we are a trustworthy partner with over 43 years of experience within Singapore. Our R&D operations started 15 years ago within the military and we are the partner of choice for Singapore's Ministry of Defense. Research and the subsequent technologies remain the backbone of our company, and in collaborating with our stakeholders, we believe that the key to sustainable partnerships is to work on R&D together.

### Why is Singapore a strong location for Thales' space operations?

Singapore is a solid location to test satellite technologies because it is located close to the equator, which allows for higher performance results. We can receive very high-coverage with only one satellite given that each orbital period lasts approximately 1.5 hours. To achieve the same results further north, we would need to deploy a constellation of satellites. Whenever we want to ramp up a new service, for instance, it is good to first deploy it on the equatorial belt, between +/-15 degrees latitude. This will enable us to later expand it to a global coverage.

There is also the benefit of having demanding customers in the high-tech space in Singapore. This means that our operations are always held to the highest standards, which allows Thales to develop the best products for the future.

### Which new developments can we observe with nano- and micro- satellite technologies?

For example, nano-satellites are starting to have some on-board propulsion, which is opening the door to formation flying or flying alongside a large satellite. This is a very important and recent development, and it is a key enabling technology that Singapore is positioned to develop.

Many new and impactful applications could be demonstrated in/from Singapore for both military and civilian needs, for instance in the fields of Earth observation, meteorology, navigation, data collection, telecommunications etc., leveraging on Thales excellence in optical and microwave satellite payloads, platforms and systems. In the long run, these new developments should impact the growth of satellite activities in Singapore.

## Conclusion

By Elisa L. Iannaccone and Alice Pascoletti

Although Singapore has only been a country for just over 50 years, the rate at which its industrial capabilities and capacity have grown is extraordinary. The government's push for developing the country through the EDB, A\*STAR and SPRING has aided dozens of companies in the pursuit of establishing their operations successfully in Singapore. Both SMEs and MNCs have the well-established regulatory framework to support each of their needs. There is an overall ease of doing business in the country, where businesses can trust that they are in reliable hands, and although the cost of living and skilled labor is continuously on the rise, tax benefits, 24 hour customs clearances, airport expansions, infrastructure, numerous R&D institutions and a prime geographical position are only a few of the reasons why companies decide to operate from Singapore as a hub in the Asia Pacific Region.

The aerospace industry is a driving force behind Singapore's growth. With a strong MRO position that the country aims to maintain, Singapore is now looking to grow the manufacturing sector and to broaden the value chain offering in the country. Major investments by key players

in the industry are also an indication that companies are here to stay and are continually expanding and investing into their operations. The expansion plans at Changi Airport are a way of planning for the future in order to avoid the congestion that is currently experienced by many cities in the region, including Hong Kong, which is another regional hub. SAP has become a tight knit community of industry giants, as well as national companies that are looking to collaborate with others within the sector. Once again, Singapore's history of surviving on the back of mutual cooperation and collaboration resonates across the aerospace industry.

Singapore's push to becoming a cutting-edge technology leader is also rippling across the industry. R&D centers are investing heavily in the development of automation, robotics, VR, IA, and UAV technologies, which can all be implemented in order to aid the skilled labor shortages in the country and improve a company's operations across the value chain. There is also a strong focus on developing space technologies. Satellite and telecommunications innovations generated through the use of HTS and IDRS implementation

are changing the landscape of the industry world-wide. Though Singapore will not be able to compete in all-things space given its land limitations and young space industry, its potential to become a niche-technology hub is well on its way to being realized. It may still take some time to create a national space agency, but the general sentiment of the companies operating within the space realm is that it will inevitably come. New IoT sensors are being implemented across the board to explore all the data that can be processed through data analytics. Some have referred to the importance of developing ways in which machines and infrastructure can communicate amongst themselves in order to make M2M decisions. Exploring the ways in which both space and Industry 4.0 technologies can be implemented and commercialized is of great importance to the industry today. Justifying the cost of both automation and space exploration is becoming more difficult, but if ways to impact business operations on Earth can be addressed at the same time, the speed at which these will take place will increase substantially. Singapore is in the midsts of developing a strong talent pool of trained professionals and manpower that can assist the industry and meet its needs. Despite the costs and resourcing challenges, Singapore remains a reliable partner, with a government, industry and educational backing that work in unison towards the common goal of strengthening the country's position as an aerospace hub. —



Image: Bell Helicopters



# Companies

|   | Actuation and Landing Gear | Aerospace Services | Comm. Systems and Equipment | Components and Standard Parts | Design, Interiors and Exteriors | Industrial Engineering |  | Machinery and Equipment | Manufacturing | Mapping and Remote Sensing | MRO | Navigation Systems and Equipment | Sub-assemblies and Structures | Systems and Software | Testing and Maintenance | Training | Treatment and Processing |
|---|----------------------------|--------------------|-----------------------------|-------------------------------|---------------------------------|------------------------|--|-------------------------|---------------|----------------------------|-----|----------------------------------|-------------------------------|----------------------|-------------------------|----------|--------------------------|
| A*STAR  |                            | ✓                  | ✓                           | ✓                             |                                 | ✓                      |  | ✓                       | ✓             | ✓                          | ✓   | ✓                                | ✓                             | ✓                    | ✓                       |          | ✓                        |
| Accuron Technologies                            |                            |                    |                             |                               |                                 | ✓                      |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| ACSOA   |                            |                    |                             | ✓                             | ✓                               |                        |  |                         | ✓             |                            | ✓   |                                  |                               |                      |                         |          |                          |
| Addvalue Technologies                           |                            |                    | ✓                           |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| Air Transport Training College                  |                            |                    |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         | ✓        |                          |
| Asia Technical Services                         |                            |                    |                             |                               | ✓                               |                        |  |                         |               |                            |     |                                  |                               | ✓                    |                         | ✓        | ✓                        |
| Association of Aerospace Industries (Singapore) |                            |                    |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| ATR   |                            |                    |                             |                               |                                 |                        |  |                         | ✓             |                            |     |                                  |                               |                      |                         |          |                          |
| Aviation Labour Group                           |                            | ✓                  |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| Aviation Safety and Training                    |                            |                    |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         | ✓        |                          |
| Bell Helicopter                                 |                            |                    |                             |                               |                                 |                        |  |                         | ✓             |                            |     |                                  |                               |                      |                         |          |                          |
| Bombardier                                      |                            | ✓                  |                             |                               | ✓                               |                        |  |                         | ✓             |                            | ✓   |                                  |                               |                      | ✓                       | ✓        |                          |
| CAPA - Centre for Aviation                      |                            |                    |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| Composite Technology International              |                            | ✓                  |                             |                               |                                 |                        |  |                         |               |                            | ✓   |                                  |                               |                      |                         |          |                          |
| Cyient  |                            | ✓                  |                             |                               | ✓                               |                        |  |                         |               |                            | ✓   |                                  |                               | ✓                    | ✓                       |          |                          |
| Embraer   |                            |                    |                             |                               |                                 |                        |  |                         | ✓             |                            |     |                                  |                               | ✓                    |                         |          |                          |
| Esterline Sensors Services                      |                            |                    |                             | ✓                             |                                 |                        |  |                         | ✓             |                            | ✓   |                                  |                               |                      |                         |          |                          |
| Excel Aerospace                                 |                            | ✓                  |                             | ✓                             | ✓                               |                        |  |                         | ✓             |                            | ✓   |                                  | ✓                             |                      |                         |          |                          |
| Fokker Services Asia                            |                            |                    |                             | ✓                             |                                 |                        |  |                         |               |                            | ✓   |                                  |                               |                      |                         |          |                          |
| Images In Motion                                |                            | ✓                  |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| JEP Precision Engineering                       |                            |                    |                             | ✓                             |                                 |                        |  |                         | ✓             |                            |     |                                  |                               |                      |                         |          |                          |
| JTC   |                            | ✓                  |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| Lufthansa Systems Asia Pacific                  |                            |                    |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| Lufthansa Systems GmbH & Co.KG                  |                            |                    | ✓                           |                               |                                 |                        |  |                         |               |                            |     |                                  |                               | ✓                    | ✓                       |          |                          |
| Mitsubishi Electric Asia                        |                            |                    | ✓                           | ✓                             | ✓                               | ✓                      |  | ✓                       | ✓             | ✓                          |     | ✓                                | ✓                             |                      | ✓                       |          |                          |
| Rolls-Royce                                     |                            |                    |                             |                               |                                 |                        |  |                         | ✓             |                            |     |                                  |                               |                      |                         |          |                          |
| Sabena Technics Asia                            | ✓                          | ✓                  | ✓                           | ✓                             | ✓                               | ✓                      |  | ✓                       |               |                            | ✓   | ✓                                | ✓                             |                      | ✓                       | ✓        | ✓                        |
| Singapore Aerospace Manufacturing               |                            | ✓                  |                             |                               |                                 |                        |  | ✓                       |               |                            |     |                                  |                               |                      |                         |          |                          |
| Singapore Economic Development Board            |                            |                    |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| Singapore Institute of Aerospace Engineers      |                            | ✓                  |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| Singapore Space and Technology Association      |                            | ✓                  |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         | ✓        |                          |
| Singapore Technologies Aerospace (ST Aerospace) | ✓                          | ✓                  |                             | ✓                             | ✓                               | ✓                      |  |                         | ✓             |                            | ✓   |                                  | ✓                             | ✓                    | ✓                       | ✓        |                          |
| Spacetime Technology                            |                            | ✓                  | ✓                           |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| Starburst Accelerator                           |                            | ✓                  |                             |                               |                                 |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |
| Thales Singapore                                |                            | ✓                  | ✓                           | ✓                             |                                 | ✓                      |  |                         | ✓             |                            | ✓   | ✓                                | ✓                             | ✓                    | ✓                       | ✓        |                          |
| The Boeing Company                              |                            |                    |                             |                               |                                 |                        |  |                         | ✓             |                            |     |                                  |                               |                      |                         |          |                          |
| Wah Son Engineering                             |                            |                    |                             |                               |                                 | ✓                      |  | ✓                       | ✓             |                            | ✓   |                                  | ✓                             |                      | ✓                       |          |                          |
| Zero G Design                                   |                            |                    |                             |                               | ✓                               |                        |  |                         |               |                            |     |                                  |                               |                      |                         |          |                          |

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**Association of Aerospace Industries (Singapore)**

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www.aais.org.sg

**ATC Coating**

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Singapore 738957  
+65 6362 1200  
www.atc-treatment.com

**ATR (Avions de Transport Regional)**

51 Changi Business Park Central 2, #08-02 The Signature,  
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+65 6548 3386  
www.atr-aircraft.com



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www.aviall.com

**Aviation Labour Group**

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Singapore 529508  
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www.aviationlabour.com

**Bell Helicopter Asia**

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www.bellhelicopter.com

**BOC Aviation**

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www.bocaviation.com

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www.boeing.com

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www.bollore-logistics.com

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**CAE International Holdings Singapore Branch**

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www.cae.com/worldwide- presence/cae-singapore-training-  
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**CAPA — Centre for Aviation**

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www.centreforaviation.com

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**Civil Aviation Authority of Singapore**

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www.changiairport.com.sg, www.caas.gov.sg

**Composite Technology International**

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**Fokker**

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**International Engine Component Overhaul**

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Singapore 507102  
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www.ieco.com.sg

**FTS Flighttech Systems**

#05-10, CT Hub,  
Singapore 339407  
www.fts-aereo.com

**JET Aviation**

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www.jetaviation.com

**GE Aviation, Engine Services - Singapore**

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www.ge.com

**JEP Precision Engineering**

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**Lufthansa Technik AG**

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**Mag Engine Systems**

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www.rolls-royce.com/country-sites/singapore.aspx

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www.sabenatechnics.com

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www.safran-electronics-defense.com/company/safran-electronics-defense-services-asia-pte-ltd

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