Productivity Link

September 2015

Contents

Productivity in Precision Engineering

1. An Overview of Precision Engineering Industry in Singapore

Precision engineering involves the design and implementation of components for diverse and varied industries around the globe. These industries include aerospace, petroleum production, gas drilling, and even diamond and other mineral mining. Precision manufacturing began in Singapore in the early to mid 1970s and has spanned fifty years. In that short time, it has grown to encompass more than 2700 companies in Singapore. These companies range from very small to mid-sized enterprises and even include some very large and diverse multi-national corporations. From contractors to full-solution providers, these companies offer prototyping, supply chain management and production to other companies and corporations around the world.

Among the key reasons for the global leadership of Singapore in areas such as aerospace, semi-conductors, and oil and gas production, are their activities in the precision engineering arena. Singapore has moved from humble beginnings as a simple contract manufacturer to being a solution provider. It offers strong prototyping, design, producing and even supply chain management capabilities today to companies and countries around the world. The precision engineering companies in Singapore offer a broad scope of different products and services to many different companies and countries. Singapore manufacturers are responsible for keeping some of them in business in manufacturing.

2. The Future of Precision Engineering in Singapore

According to Singapore Precision Engineering and Technology Association (SPETA) in its “Precision Engineering Industry – Growth, challenges and future” presentation on 15 April 2015, manufacturing is one of the key engines of growth for the Singapore economy and Precision Engineering Industry forms the backbone of manufacturing. The government’s long term goal is to maintain the contribution of manufacturing to GDP at 20%.

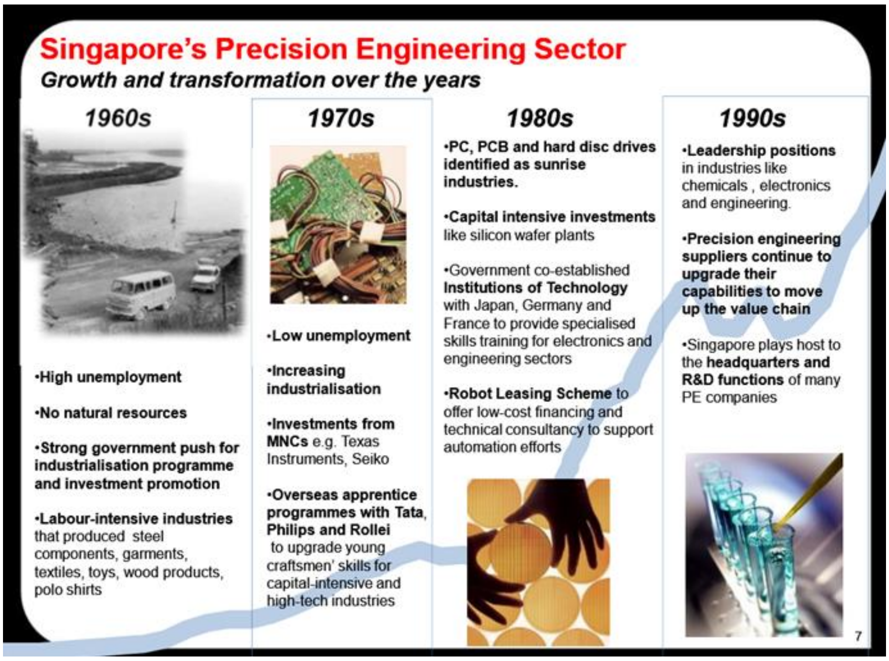

Figure 1: Singapore's Precision Engineering Sector over the years
Source: http://www.simtech.a-star.edu.sg/PECOI/media/8319/2.speta_presentation_2.pdf

Singapore is currently seeing new areas of growth in the manufacturing and precision engineering arena, including environmental engineering, clean energy and natural resource production. These areas of production have expanded to encompass an even greater portion of the world marketplace, moving into areas such as Oceania, India and China.

Fixed asset investments have seen a new high from Singapore, rising to whole new levels of competition in the global marketplace. As Singapore becomes increasingly more competitive and branches out further into the market, greater productivity and management will be necessary in order to compete on a level playing field.

In 1960, precision engineering and manufacturing accounted for only a minute percent of the GDP in Singapore and unemployment stood at 13 percent. Today, that has changed dramatically with precision engineering and manufacturing accounting for US $71K per capita and the unemployment rate having fallen to a massively different 1.8 percent in 2013.

In the last two decades alone the precision engineering sector in Singapore as increased their output by nearly four times. In the last year alone, it contributed more than $7 billion dollars to the economy and employed more than 90 thousand workers.

How can Singapore achieve that level of competition and what can we do to provide for greater efficiency and productivity in the precision engineering field?

Precision engineering is a core enabler for a wide range of different manufacturing arenas. These include medical devices, IoT (Internet of Things) wearables, oil and gas, aerospace technology and sea and ocean exploration. Precision manufacturing encompasses small chips such as semiconductors and drill bits, to mechanical hearts and transportation.

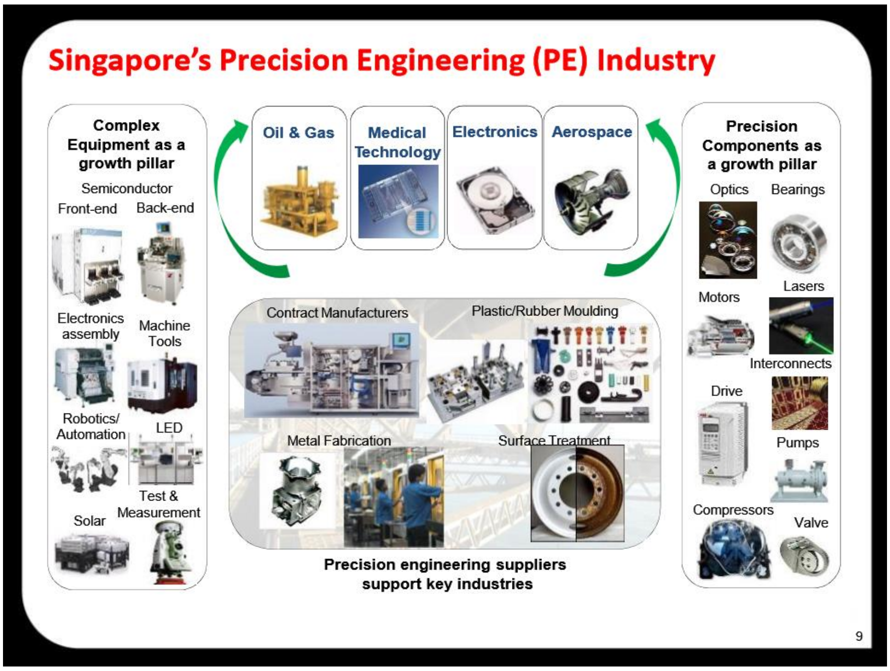

Figure 2: Singapore's Precision Engineering Industry
Source: http://www.simtech.a-star.edu.sg/PECOI/media/8319/2.speta_presentation_2.pdf

Singapore is currently home to a very broad range of precision engineering interests. These primarily include medical devices such as hearing aids. Singapore is home to about 30 percent of hearing aid production, while the semiconductor industry relies on Singapore for as much as 70 percent of the wire bonders that are necessary. About 10 percent of refrigeration compressors are created in Singapore and is one of the leading manufacturers of oil and gas equipment, much in demand today in the pursuit of energy independence for the United States and Europe.

Aerospace maintenance, overhaul and repair is also, to a large extent, manufacturer in Singapore. What this means is that in order to keep our edge in this precision engineering marketplace, Singapore must become even more productive, grow and adapt to a changing global marketplace.

3. Challenges to productivity Precision Engineering

As in any other field, there are challenges to overcome when seeking ways to improve productivity and increase profits. The key challenges the precision manufacturing field is facing today are not unique to Singapore, but globally as well. These challenges are explored below.

- The need for standardisation in precision engineering.
- The need for speedier and more rapid return of orders placed in order to compete with larger companies and suppliers.
- The need for more technical and more diverse products and services.
- Productivity improvements in manpower will require additional training for the workforce in order for them to use some of the key enablers.
- Increased use of technology highly technical aspects of manufacturing will be necessary.
- Engagement of talented workers who are driven to succeed for the company.
- Formation of alliances with other companies who can provide some of the education and training as well as the know-how to use new technology will be necessary in the long term.
- Shipping and supply chain challenges that must be met and overcome in order to ensure the timely shipment of products.

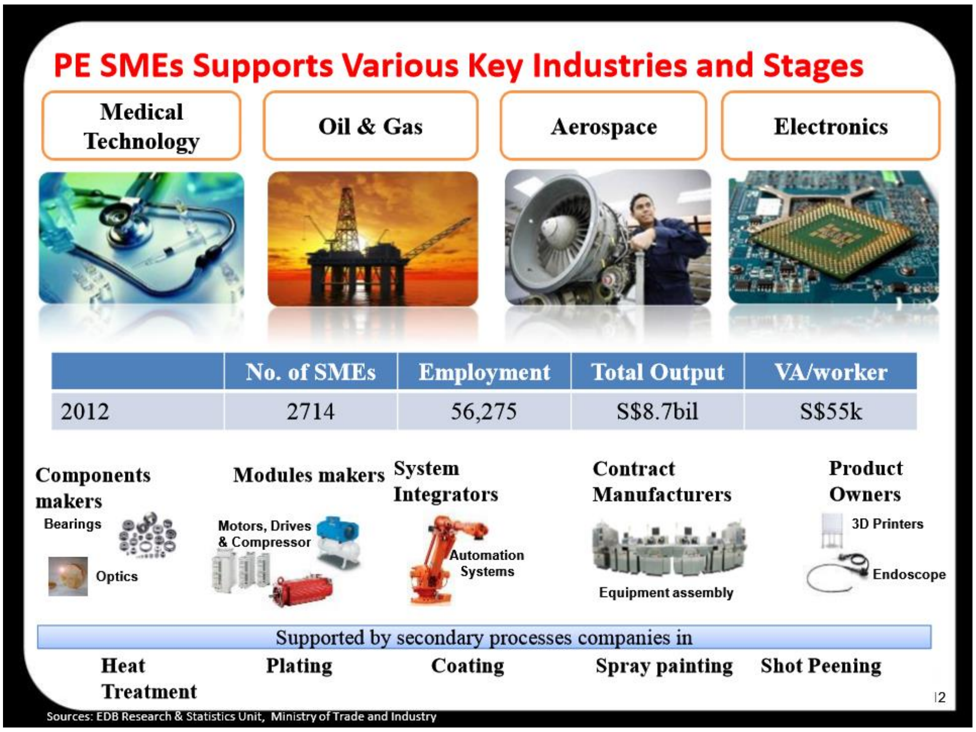

Figure 3: PE SMEs supports various key industries and stages
Source: http://www.simtech.a-star.edu.sg/PECOI/media/8319/2.speta_presentation_2.pdf

4. Key Enablers and Disruptive Technologies in Precision Engineering

Today there are, thankfully a broad array of different types of assistance that can help us improve and increase our productivity in the precision engineering sector. Not all of these may be suitable for every company or every individual. Each of them may add challenges to the fray in that they will require some additional outlay of funding for equipment and/or training to use the equipment before bearing the fruits of improved productivity. Some of the key enablers are discussed below.

4.1 3D Printing Technology

One of the key enablers today in precision engineering and manufacturing is that of the 3D printer. 3D printers can work with materials that span the gamut, from plastic to titanium, to human cartilage.
They can produce the smallest components to the largest ones. These include LEDs (light emitting diodes), batteries, transistors, even bricks for building homes. The capabilities of 3D printers are expanding rapidly and they are becoming a very viable and very speedy alternative to the more conventional methods of manufacturing.

In contrast to traditional machining methods that typically cut parts out of larger pieces to get to a finished shape, additive manufacturing uses lasers to fuse thin layers of metal on top of each other to build parts from the ground up. This advanced technique means less material waste and more complex parts that can be built precisely to optimize how they work inside a machine.

GE Aviation development team has already registered a major victory for using additive manufacturing in producing aircraft components. They designed and developed a fuel nozzle that will be additively manufactured for inclusion in the CFM LEAP jet engine for commercial single-aisle aircraft. The engine is currently being tested. However, the FAA recently approved the first 3D printed component for a version of the GE90 jet engine.

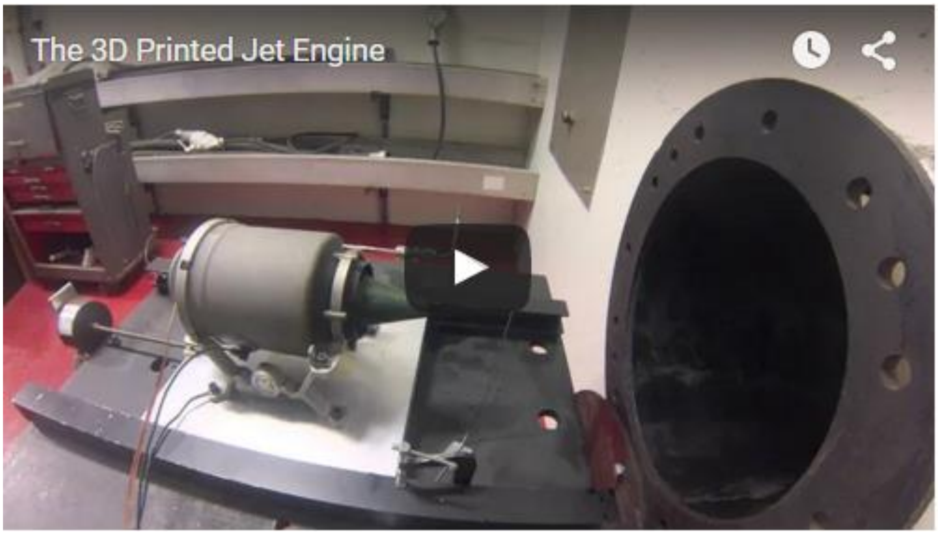

Figure 4: The 3D Printed Jet Engine
Source: http://www.gereports.com/post/118394013625/these-engineers-3d-printed-a-mini-jet-engine-then

3D printing requires fewer people to accomplish the same things and can speed the production dramatically. The challenge is, 3D printing requires trained personnel to operate them efficiently and effectively, meaning that they would require an original outlay for materials and equipment as well as training for those who will be operating them.

However, the benefits of using 3D printing could be far reaching as they can effectively lower the cost of manufacturing through a far more timely and efficient way. Companies could slash manufacturing time to a third of what it is today, lowering the time for output of larger orders and lowering the cost in manpower involved in the manufacturing process.

These 3D printers can be used to make anything and everything from artificial blood vessels to artificial hearts down to the smallest components of electrical circuit boards, even low cost prosthetics that could make it possible for those who have not been able to afford one to have it.

12 Things 3D Print is used in Medicine:
1. Tissues with blood vessels
2. Low–Cost Prosthetic Parts
3. Drugs
4. Tailor-made sensors
5. Medical Models
6. Bone
7. Heart Valve
8. Ear cartilage
9. Medical equipment
10. Cranium Replacement
11. Synthetic skin
12. Organs
Source: http://3dprintingindustry.com/2015/02/26/12-things-we-can-3d-print-in-medicine-right-now/

4.2 Robotics in Precision Manufacturing

Robotics is another method of changing and improving the overall precision engineering sector. The use of robotics can speed up the processes and make them far more cost effective. Imagine the use of robotics to move goods from one point to another--to place them into storage or take care of and control the warehousing. Supply and shipping being handled by robotics would lower costs dramatically, prevent injury, and save time as well.

Another way that robotics can be used that will dramatically save money is, as in the case of NYSEARCH, the Northeast Gas Association's research and development branch. Working with Honeybee Robotics they designed, built and tested a novel approach to natural gas distribution cased pipe sections. "The robot inspection system can access pipes that were previously accessible only by costly and disruptive excavation."

The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF) has made strides in optimizing the industrial production line. Researchers have created robots fitted with a gripper tool, a laser and an advanced camera that can recognize various parts and their positions in 3-D. They used a CAD model to tell the robot which item to pick and taught the robot to recognize the wheel and it position in the box so that it can grip it accurately regardless of its position in the box.

Using the LAAM system, the repair time for some parts was reduced from 4 days to 20 minutes

Figure 5: Robotised Laser Aided Additive Manufacturing (LAAM) System

Source: http://www.simtech.a-star.edu.sg/industry/industry-collaborations.aspx#CompleteProj

5. Possible Immediate Next Steps

Precision Engineering companies can capitalise on disruptive technologies such as optics and laser, additive manufacturing and advanced robotics to boost productivity. Figure

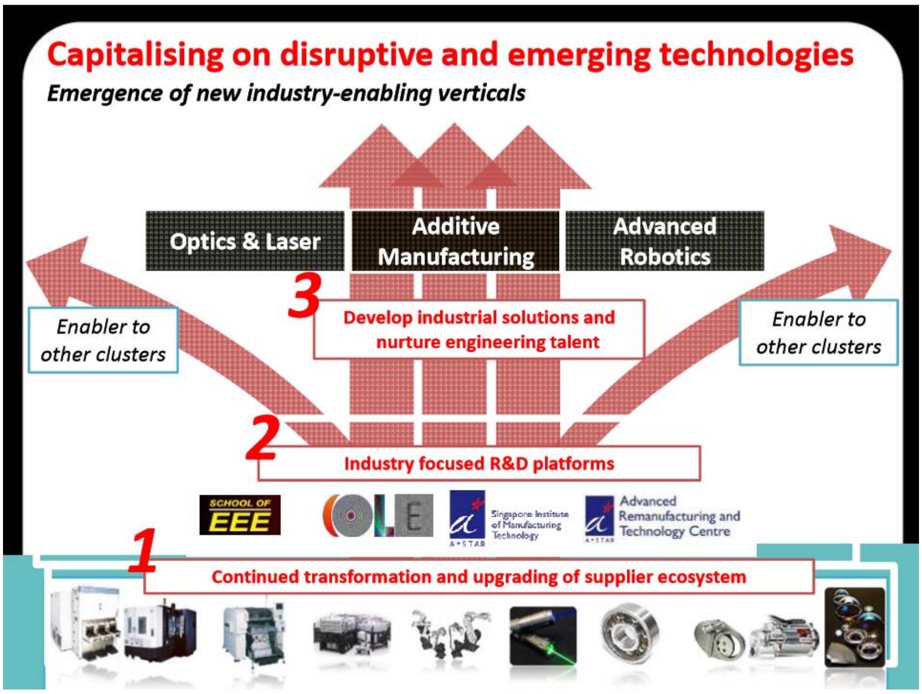

Figure 6: Capitalising on Disruptive Technologies
Source: http://www.simtech.a-star.edu.sg/PECOI/media/8319/2.speta_presentation_2.pdf

A key starting point is to invest in the training of employees. The diagram below shows the training roadmap for PE talent.

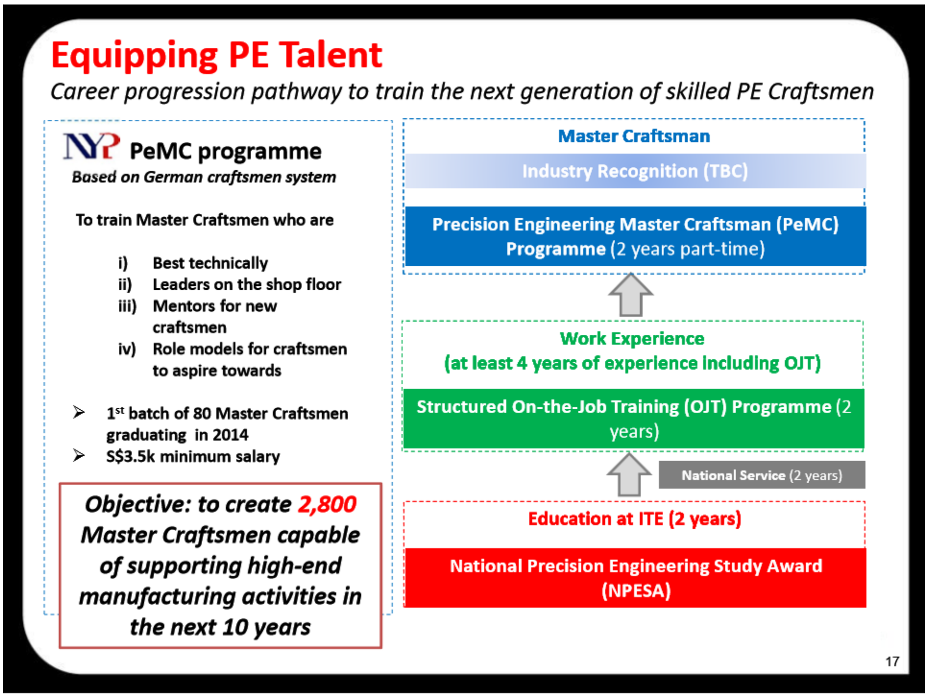

Figure 7: Equipping PE Talent
Source: http://www.simtech.a-star.edu.sg/PECOI/media/8319/2.speta_presentation_2.pdf

Case Study

Case Study 1: Singapore - Fibre Draw Tower – Singapore Nanyang Technological University

The Fibre Draw Tower is a state-of-the-art fibre fabrication centre. It is fully equipped and lies at the Centre of Optical Fibre Technology (COFT), an affiliated centre under the umbrella of The Photonics Institute (TPI) Funding for this million-dollar equipment was contributed generously by the Agency for Science, Technology and Research (A*STAR), one of TPI's research partners.

The Fibre Draw Tower was delivered in April 2014 and commissioned in August 2014, is 8.5m tall (equivalent to 3 storeys) and the first of its kind in Singapore, capable of drawing fibres at a rate of up to 200m/min.

Figure 8: Fibre Draw Tower
Source: http://tpi.ntu.edu.sg/research/Pages/Special-Feature-COFT-Fibre-Drawing-Tower.aspx

The outer diameter of the fibres drawn from this tower can range from as small as 80um, to as large as 800um (prior to application of coating).

In achieving the desired fibre diameter and fibre tension, the tower operator needs to have good control of 3 key parameters: the furnace temperature, the rate at which preform is fed into the furnace (preform feed speed) and the rate at which the fibre is being pulled from the tower (fibre draw speed).

A unique feature of this tower is that it is dual-sided, allowing for a variety of preforms to be drawn into fibres.

The Results:

A flexible robotised precision finishing system for large complex aerospace parts. Comprehensive calibration method, error compensation and force control technology, finishing accuracy of +/- 0.2 mm. Quality and productivity is improved, with successful implementation in a work cell.

Case Study 2: United States - Pratt and Whitney, Airplane Manufacturer

Studies were done using 3D printing for aero engine parts (Pratt & Whitney). When engine maker Pratt & Whitney delivers its first PurePower PW1500G engines to aerospace giant Bombardier for its C series passenger aircraft, the engines will be the first to feature jet engine parts that were produced using additive manufacturing (AM).

Previously, safety concerns prevented Pratt & Whitney from using the technique for production engine components.Today those safety concerns are no longer an issue for the company.

While Pratt & Whitney has produced more than 100,000 prototype parts using additive manufacturing over the past 25 years, the company says it will be the first to use AM technology to produce compressor stators and synch ring brackets for the production engines; PurePower PW1500G engines exclusively power the Bombardier C Series aircraft family.

3D-printed: P&W's compressor stators.

AM components for Bombardier's CSeries aircraft family.

Figure 9 : Pratt & Whitney’s use of additive manufacturing and 3D printed components
Source: http://optics.org/news/6/4/7

The Results:

Lynn Gambill, chief engineer, Manufacturing Engineering and Global Services at Pratt & Whitney, commented, "Additive manufacturing offers significant benefits to the production of jet engines. We have engine tested components produced through additive manufacturing in the PW1500G.

“AM offers a number of benefits: It dramatically reduces production time, from design, to prototyping, to finished product and it decreases waste and consumption of raw materials. Furthermore it allows precision production of parts with complex geometry with reduced tooling, and permits multiple parts from an assembly to be made in one integrated piece.”

Pratt & Whitney added that in production tests, it has realized up to 15 months lead-time savings compared to conventional manufacturing processes. Further it has achieved a 50% weight reduction in a single part. The Pure Power engine family parts will be the first product produced using 3D printing powder bed additive manufacturing.

6. Conclusion

Leveraging on the support from the government and various trade associations, many Precision Engineering SMEs have transformed from parts contract manufacturers to having capabilities in design and manufacturing of endoscopes or from trading companies to product owners. This paves the way for the industry to move towards the vision painted by SPETA that by the year 2020, Singapore could become a centre of Precision Engineering Excellence.

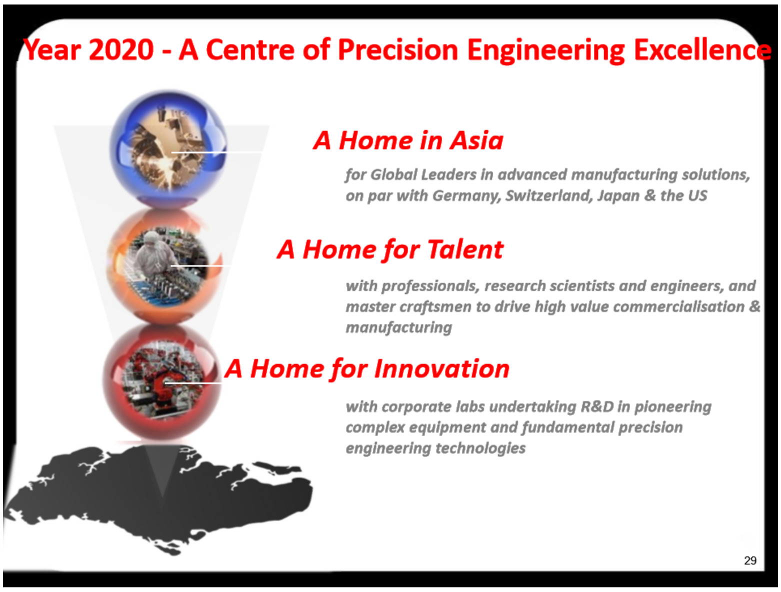

Figure 10: SEPTA's vision for PE Industry in Singapore
Source: http://www.simtech.a-star.edu.sg/PECOI/media/8319/2.speta_presentation_2.pdf

Recommended Readings

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Author(s): Chua Chee Kai, Leong Kah Fai.
Publisher: Singapore ; Hackensack, NJ : World Scientific
Year of Publication: 2015
ISBN: 9789814571418
Call Number: 620.0042 CHU

Title: Radical abundance: How a Revolution in Nanotechnology Will Change Civilization.
Author(s): K. Eric Drexler
Publisher: Public Affairs
Year of Publication: 2013
ISBN: 978-1610391139

Title: Semiconductor Laser Engineering, Reliability and Diagnostics: A Practical Approach to High Power and Single Mode Devices
Author(s): Peter W. Epperlein
Publisher: John Wiley & Sons
Year of Publication: 2013
ISBN: 9781119990338

Publications which are in the holdings of the National Library or Public Libraries are denoted by [call number] at the end of each reference. Please check the library's online catalogue to confirm the availability.

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