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Insights

DEEP TECH INVESTMENTS:

Realising the Potential

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(arranged alphabetically by institution)

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1.

INTRODUCTION

Globally, tens of millions of tech startups are founded every year, the majority of which fall into the Internet, mobile, e-commerce and collaboration/messaging sectors. After years of shying away from science, engineering, clean technology and medical technology startups, investors are beginning to invest in them. Collectively, these startups focus on what is called deep technology that is based on hard core scientific research and backed by patents. But these startups face intense pressure to prove that their science can turn out huge revenues as quickly as the general tech hot consumer companies.

Deep technology, or Deep Tech, offers the chance to solve big societal problems in healthcare, urban mobility and other issues. But alongside the opportunities are the challenges. Commercialisation of scientific discoveries are high risk ventures which require large investments. They also need "patient" capital, that is, investors must patiently wait for financial returns. But because it has challenges, it does not mean that Deep Tech is not a good investment territory.

This in-depth feature seeks to create greater awareness of the Deep Tech sector and its potential as an investment asset.

Deep Tech is well developed in the US and Europe. In the Asia-Pacific region, China has streaked ahead. In the past 20 years, it has invested heavily in artificial intelligence and life sciences. Among Southeast Asian countries, Singapore's Deep Tech sector has seen gradual development. Years of support by the Singapore Government has led to the establishment of a good startup ecosystem. However, most of the startups are in the general tech sector. Deep Tech has a weaker ecosystem with fewer funds able to support such startups throughout their long gestation period. There is also a small dealflow of potential projects.

Three case studies highlighted in this Insights Paper illuminate the opportunities and challenges of translating research into a business as well as Deep Tech entrepreneurship in Singapore.

The discussion in this Insights Paper introduces the concept of Deep Tech, describes the differences between Deep Tech and general tech, highlights the challenges and discusses its risks versus rewards. It includes an overview of the Deep Tech landscape with a section highlighting the Singapore experience. Rounding up this paper are insights drawn from the research.

This Insights Paper is made possible with the perspectives and views gathered from policy-makers, investors and entrepreneurs.

2.

WHAT IS DEEP TECH?

Think Deep Tech as the PhD holders' startup club where these scientists and engineers with PhDs and advanced degrees are solving large problems facing the world such as global warming, fighting cancers and traffic congestions.

No Angry Birds. No video gaming, messaging apps or media portals.

Deep Tech can also be seen through the lens of Industry 4.0, where we are seeing rapid advances in technologies that are physical (autonomous vehicles, new materials, 3D printing, advanced robotics) or biological (genetic engineering, neurotechnology, bioprinting).

Deep Tech as a phrase has entered the startup lexicon. It was first coined in 2014 by investor Swati Chaturvedi of VC firm Propel(x). She wanted to differentiate the Deep Tech firms from the mass of general tech startups engaged in Internet, mobile and e-commerce work that are based on business model innovation, incremental service improvements or the deployment of standardised technologies.

A quick background on how Deep Tech startups are floated up to investors. VCs and seasoned investors work with a dealflow which is a pipeline of potential startups. This pipeline is filled by their global VC/investor networks as well as various scientific communities such as universities, research institutions and innovation centres. VCs and investors sieve through them to identify the ones that fit their investment focus and who are at a suitable development or commercialisation stage.

Once a VC or an investor is close to a funding decision, then the investment team will meet the entrepreneurs and scientific talent behind the startup for a final assessment and to address specific areas. Such companies are generally located in one of the Deep Tech centres such as Boston (medtech) and Silicon Valley (artificial intelligence).

Deep Tech VS General Tech

General tech startups began in a big way with the arrival of the Internet in the 1990s. It is usually sparked off by an idea to disrupt a traditional business process. They are usually business-to-consumer (B2C) offerings. The strategy is to grow rapidly by raising funds to acquire as many customers as possible, and at the same time try to generate revenue. Few survive this growth journey. Some hang on, kept alive by venture funds instead of fading and dying quickly.

Funding can be as low as US$10,000. Follow-on funding can sometimes be as high as US$1 billion if the objective like super app Grab is to acquire customers quickly in as many countries as possible.

FACTORS	DEEP TECH	GENERAL TECH
Idea	Scientific discovery or engineering innovation	Business innovation
Qualification	Typically Postgraduate, PhDs	Often self-educated programmer, new computer science graduates
Age of founders	Usually from 35 years old and above	Usually 20-25 years old
Gestation	Typically above 5 years	From months to a few years
Testing	Multiple in-depth trials	Rapid iteration on-the-go
Regulatory approval	Yes	Not necessary

On the other hand, a Deep Tech company starts with a technology, usually based on an innovation or discovery in the lab by doctoral students and research scientists. The combination of technology and scientific talent forms the backbone of the startup. They are in fields like the life sciences, medical technology, clean technology, renewable energy, autonomous technology and other specific domains.

Commercialising Deep Tech products requires many years. Research takes years before a discovery emerges. Translating the research into products is time consuming because the discovery has never been seen before and must be tested for safe use. Tests especially clinical trials involving people require a few rounds and are tedious to organise. Regulatory approval if needed, must be submitted to individual governments.

Larger funding is required since labs and equipment are expensive. So are research talent. Funding can start small as low as US$1 million but can escalate to hundreds of millions and billions over the years.

The risk of failure is high for both Deep Tech and general tech startups, the norm is nine out of 10 fail. But investments in general tech are generally lower, so the financial loss is smaller.

Entrepreneurial scientists also lack knowledge on how to frame their effort into something that can be commercialised. Their concept of time to market and completeness of solution, may not be obvious. A Singapore medical doctor who invented a heart monitoring device discovered he had no knowledge on how to found a startup. His learning curve was steep, he had to find out how to incorporate a company, hire staff and raise funds. He persisted but he lost valuable time which could have been used to bring the device quicker to the market.

While young or fresh graduates of general tech startups may face similar challenges, their route to the market is faster. A prototype can be available in the first 12 months and a final product is ready the next year. In contrast, hard core science takes years of research and many more years to turn the discovery into a market-ready product.

Examples of Deep Tech startups in various stages of development around the world and in Asia.

Genentech is a US company, one of the earliest and more successful biotech companies. Founded in 1976, it pioneered a new scientific field called recombinant DNA technology, to make drugs to treat diabetes, different types of cancer, multiple sclerosis and Alzheimer's disease.

Veredus Labs, a Singapore-founded molecular diagnostics kit maker was acquired by Japan's Sekisui Chemical. Founded in 2003, it makes bio-chips which can test for the Zika and Dengue viruses.

Sentient Technologies is an American AI firm, founded in 2007. Its computation platform has been used to predict sepsis in ICU patients as well as power recommendation and personalisation engines for e-commerce companies.

HistoIndex, founded in 2010, is in medical diagnostics, helping researchers to automate the diagnosis of fibrosis and cancer tissues quickly and accurately. It was spun off from Singapore's Institute of Biotechnology and Nanotechnology (IBN).

ViSenze provides AI-based visual search and image recognition solutions to retailers. Founded in Singapore, it started as a part of NExT, a research centre jointly set up between National University of Singapore and Tsinghua University of China.

Aslan Pharmaceuticals, founded in Singapore in 2010, develops drugs for cancer types prevalent in Asia like biliary tract cancer, breast cancer and gastric cancer. It raised US$42 million when it was listed in 2018 on Nasdaq in the US.

Third Wave Power, founded in 2016 in Singapore, developed renewable power solutions for urban and rural areas.

Awak Technologies, a Singapore-based medical technology startup, offers dialysis using regeneration technology for end-stage renal disease. It has been granted FDA Breakthrough Device designation for Awak Peritoneal Dialysis (PD) device, a wearable and ultra-portable PD system that incorporates Awak's patented sorbent technology. The 1kg machine can be worn on a belt or carried in a bag so patients can have water dialysis around the clock.

Investment evaluation of Deep Tech startups is hard, especially if the subject matter is life sciences and medical technology. It is not infrequent to find excellent research with an estimated time to market of at least 10 years, which is beyond the lifetime of any fund which commonly has a life span of 10 years.

Moreover, investors and entrepreneurs must have the domain expertise to be able to really understand the impact of the new discovery or innovation in order to gauge risk.

Another difference with general tech startups is the considerable duration needed for commercialisation. Exits for Deep Tech investors and entrepreneurs are usually through acquisitions although few are publicly listed. This process frequently takes many more years than general tech startups.

In addition, steeped into academia, entrepreneurial scientists have little corporate and managerial experience. The risk is that they require handholding which is time consuming, a practice unfavoured by busy investors.

3.

DEEP TECH LANDSCAPE

Scientific discoveries have had a long history. Penicillin, electricity, the internal combustion engine and others have had profound impact saving lives, improving healthcare and enhancing transportation. Deep Tech will create a similar impact in the coming years. Governments around the world are stepping up their involvement and investments in this sector.

EUROPE

Deep Tech investments have seen a significant increase in Europe in recent years. An Atomico report stated that in 2017, US$3.5 billion[1] were invested in 600 Deep Tech deals compared to only 120 in 2012. The prospect of the United Kingdom leaving the European Union is expected to benefit Europe. Private sector research and innovation activities will likely move across the British Channel in anticipation of this move.

Talent and market size are two key advantages for Europe. Germany, Britain, France and other countries have many of the world's top educational institutions which turn out many PhDs in the sciences, engineering and mathematics.

The Atomico report also highlighted that software developers number about 5.5 million in Europe, 25 per cent more than the US. With a population of over 700 million, the region has a large domestic market for its startups.

Innovation is also strong in Europe. VC funding grew from €4.1billion euros (US$4.65 billion) in 2012 to €19.1 billion (US$21.67 billion) in 2017. According to Dealroom[2], Deep Tech funding rose even faster, by nearly 10 times over the same period.

On the European horizon, one big area emerging is autonomous technology.

The world's largest automotive giants are in Europe namely German firms Daimler and BMW. They are working to produce new transportation methods based on autonomous technology.

[1] State of European Tech
https://2017.stateofeuropeantech.com/chapter/deep-tech/article/european-deep-tech-seize-global-opportunities/

[2] Annual European Venture Capital Report 2017 edition

UNITED STATES

The uniqueness of the US Deep Tech startup environment is its rich ecosystem. Investors and entrepreneurs there have been investing in both general and Deep Tech sectors for decades. They have subject matter expertise in Deep Tech, possessing in-depth knowledge and technology skills. Most importantly, the investors have large funds. At least five VCs including Lightspeed Venture Partners have raised over US$1 billion in funds in 2018. There are also specific funds for Deep Tech like Global Life Sciences which has several funds, each of which is about US$55 million.

Three things give the US a huge advantage in scientific discovery and innovations.

First, it is consistently among the top three countries to file the most patents[3] globally. And the patents do translate into products and services. For example, the Recombinant DNA technology pioneered by Genentech has resulted in new drugs, generating income for the pharmaceutical industry.

Second, the US has some of the best universities in the world. Two of them, Stanford University and Massachusetts Institute of Technology (MIT) have world renown computer science, business studies, engineering and science programmes. Their alumni have founded big impactful companies such as Ginko Networks, Google, Nvidia, and Qualcomm.

Third, there is an established network comprising students, academic staff, universities and industry. This network has the inside track to the disruptive business ideas of young students as well as access to discoveries by scientific staff and new technology developments in the research labs.

Professors in this network are also clued in to what the market appreciates, that is when ideas will turn into gold. They recognise "winners", from the new ideas and findings that emerge from students and labs and which will lead to successful products.

One of the best-known academics who does this is Professor David Cheriton.

The Professor Billionaire as he is known, has a net worth of US$5.8 billion. He made his fortune from an early investment of US$100,000 in Google.

These three factors make up the "DNA" that has been baked into the startup and scientific communities in the US, giving it a unique differentiator from other countries and regions.

The US will remain a key centre for scientific research and technology development. Its highly developed ecosystem supports and accepts new disruptive and transformational technologies. It is also supported by a sophisticated investor community.

ASIA

China is obviously the elephant in the room. It is debatable whether China or the US is at the top of AI or life sciences development. Without a doubt, China is among the global world leaders in these scientific domains. Its thriving startup landscape helps push AI innovations further. Besides, its large population of 1.3 billion people create a huge domestic market. China's New Generation AI Development Plan launched in 2017 has also influenced key industries across its economy to use AI.

The Chinese Government has also invested in advanced manufacturing and robotics, blockchain, agricultural technology and new food production techniques. It is firing on all cylinders, providing large financial support to bolster its activities in the Deep Tech sector.

In other parts of Asia, Deep Tech investments are slow in picking up. In India, the Government aims to deploy Deep Tech to discover new climate resilient agricultural species, fog vision systems for road and rail and predictive maintenance of rolling stock. Japan[4] was set to spend US$107 billion in 2017 in hard core science and research. Most of the Deep Tech investments take place in North Asia and Taiwan where the developed economies there have good universities and access to large investment funds.

In Southeast Asia, the Deep Tech landscape is in its nascent stage. Of the 11 countries in the region, Singapore has the most advanced startup ecosystem but Deep Tech investments are still few and far between.

[3] World Intellectual Property Indicators 2018
https://www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2018.pdf

[4] R&D budgets in Japan soaring to record-breaking levels, Nikkei Asian Review July 27, 2017
https://asia.nikkei.com/Business/R-D-budgets-in-Japan-soaring-to-record-breaking-levels

SINGAPORE

The Republic's startup ecosystem is pretty well-developed, with about 5,000 startups, a strong and growing community of VCs including angels, and more than 100 incubators/accelerators. However, the Deep Tech sector in this ecosystem is in an embryonic stage.

Professor Wong Poh Kam, Director of NUS Entrepreneurship Centre, observed that despite significant R&D investment over several years in various Deep Tech fields, Singapore is still a laggard[5]. Said Prof Wong: "Singapore still lacks the depth and specialisation of other high-tech startup hubs, such as Boston and San Diego in life sciences, Silicon Valley in semiconductor/digital devices, big data, clean tech, and energy, and Munich in advanced engineering and manufacturing.

Indeed, while several internet/mobile ecommerce startups from Singapore have successfully scaled up regionally and achieved valuation of above S$ 500 million (US$360 million) in recent years (e.g, SEA, Grab, PropertyGuru, Carousell), there has so far been virtually no Deep Tech startup in Singapore that has successfully scaled up."

Chart 1 (see below) shows that general tech startups is in pole position with Deep Tech trailing far behind. Despite several years of Government funding, the Deep Tech sector is still small.

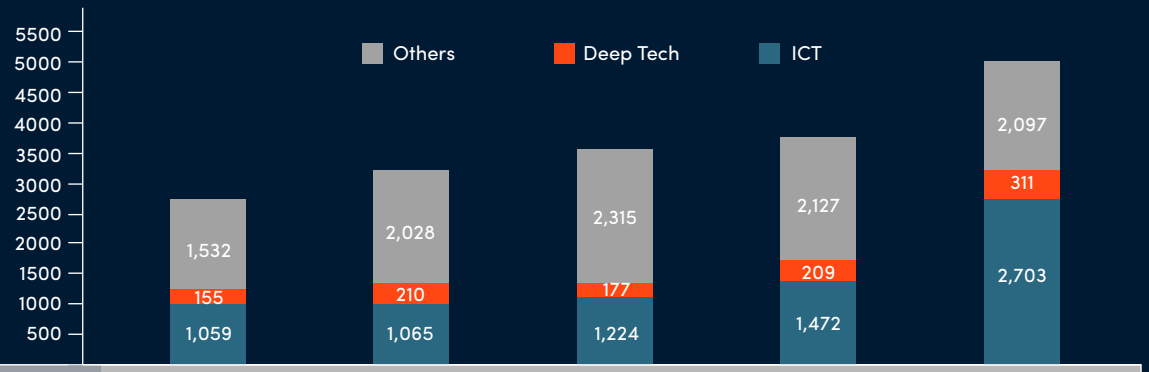
There is also a lack of a sophisticated Deep Tech investing community. Venture capital firms with large funds able to invest in Deep Tech startups are in a small minority.

Another hurdle is the long gestation period. Collaborations Deep Tech startups have with large organisations like hospitals and manufacturing companies frequently take two to three years to jointly iron out the kinks. General tech startups, on the other hand can go directly to the consumers within the first year of operations.

It is not that Singapore lacks scientific research. For a small country, about S$60 billion (US$43.3 billion) have been invested in hard science and engineering since 1995. There are many research institutions here. In 2017, there were over 35,000 research scientists and engineers[6] in Singapore.

Patents granted by the US Patent and Trademark Office to Singapore inventors have also risen more sharply from 943 between 1996 and 2000 to 7171 between 2011 and 2016[7]. However, the majority of patents are filed by foreign companies and the discoveries are usually commercialised out of Singapore.

Chart 1: Startup growth numbers



Distribution	2004	2007	2010	2012	2015
ICT	38.4%	32.2%	32.9%	38.7%	52.9%
Deep Tech	6.0%	6.4%	4.8%	5.5%	6.1%
Others	55.6%	61.4%	62.3%	55.9%	41.0%
n	2.757%	3.303%	3.716%	3.808%	3.111%

Sources: DOS and ACRA

[5] Developing Singapore's Innovation and Entrepreneurship Ecosystem: From Internet/Mobile Services to Deep-Technology Commercialization? By Professor Wong Poh Kam

[6] National Survey of Research and Development in Singapore 2016
https://www.a-star.edu.sg/Portals/81/Data/News And Events/Publications/National Survey of R&D/Files/national-survey-of-research-development-singapore-2016.pdf

[7] Developing Singapore's Innovation and Entrepreneurship Ecosystem: From Internet/Mobile Services to Deep-Technology Commercialization? By Professor Wong Poh Kam

In the Republic, Deep Tech startups face different challenges in funding and recruiting talent. Many of the startup investments originate from Government agencies, usually between S$50,000 (US$36,000) and S$500,000 (US$360,000) per investment. This may be sufficient for general Internet startups but inadequate for Deep Tech startups.

Reluctance to invest can be attributed to the same risks identified earlier in this Insights Paper: long gestation period of Deep Tech projects, small funds and lack of evaluation capability.

However, the situation is less grim and is in fact, looking brighter. There is a small community of biomedical startups, some of which have been successful like Veredus Labs[8]. Autonomous technology as it is used in driverless vehicles have also found a home in the Republic. Government support in form of new policies, funding and creating sandboxes for experiments and trials have led to a clutch of startups in this field and created a global reputation for the country in this domain.

Since the late 2000s, special incubators and accelerators have been set up like Clearbridge Accelerator and Zircom MedTech. A Cleantech Accelerator has also been set up by the Sustainable Energy Association Singapore to provide startups in this area. These are capability development efforts by the Government. In recent years, more specialised accelerators have started operations here.

SGInnovate was also set up in 2016 to build and grow Deep Tech startups. Entrepreneur First and Antler are venture creators and startup generators that emerged in recent years. Entrepreneur First received Government funding while Antler raised venture capital. Several companies have already been formed and "graduated" such as Qritive, which provides pathology labs with a workflow software and AI diagnostics to shorten the time needed to analyse tissue samples, allowing doctors to obtain results for patients more quickly.

Collaborations with global Deep Tech companies have also picked up. A global life sciences company based in Singapore is working with a local data analytics company to develop remote monitoring devices that

Dr Aneesh Sathe, CEO & Co-founder of Qritive

can monitor vital signs of patients suffering from cardiac disease. Data collected allow for early medical intervention, preventing hospitalisation and ultimately, saving lives.

A push has also started to discover promising local research that can be spun off into Deep Tech startups. The Startup SG Equity scheme, a Government-backed fund, was launched to support among other things, co-investments with private money including from individuals and family offices, in Deep Tech startups.

More initiatives have surfaced from among the local research institutions and universities to commercialise research work. A notable programme is Accelerate, the commercial arm of the Agency for Science, Technology and Research (A*STAR), which seeks to licence the technologies discovered by its scientists and engineers.

Other institutionalised programmes which seek to bring research from their organisations to the market include NUS Grip from the National University of Singapore and NTUitive from Nanyang Technological University.

To illustrate the challenges and opportunities for Deep Tech startups, three companies are highlighted here in the next two pages. They are Web Biotech, AIDA Technologies and Unum Therapeutics.

[8] Accuron Medtech divests VeredusLabs to Sekisui Chemical
https://www.businesstimes.com.sg/technology/accuron-medtech-divests-veredus-labs-to-sekisui-chemical

Case Study 1:

WEB Biotech: Full-time "over-time" entrepreneur and full-time "part-time" cardiologist

Is it possible to be an entrepreneur and a practising cardiologist at the same time? Dr Philip Wong proved it can be done but at a price. Web Biotech was founded in 2009 to develop a wearable to detect heart arrhythmia or irregular heartbeat. Called Spyder, it is a wireless, fully digital system that fully replaces the traditional wired Holter ECG system. Regulatory approval was received in 2014 with Spyder becoming commercially available in 2015.

The product could have been developed in three years had Dr Wong worked full time. Due to a lack of upfront funds, he and his co-founders worked part-time, with limited grant funding and were self-financing operational and development costs prior to first revenues.

Moreover, finding talent including a CEO, to work for a small company was tough, saddling the co-founders with many operational responsibilities that could ordinarily be delegated to staff.

Dr Wong, who works 3.5 days as cardiologist, is CEO of the startup, working with a three-member team. It is a fine balance between his two jobs since he continues to see patients during the day for salary as he does not pay himself from WEB Biotech. The remaining 1.5 days is devoted to his startup.

Currently, Spyder is in use in 30 countries. Dr Wong is looking for up to S$5 million to scale the business.

Dr Philip Wong, CEO of Web Biotech

Dr Tan Geok Leng, CEO of AIDA

Case Study 2:

AIDA Technologies: From research to startup

Formed in 2016, a small team of researchers, led by a 30-year industry veteran, Dr Tan Geok Leng, left Government research agency A*STAR, to take AI and machine learning technologies to the market. They believed these technologies can transform enterprises.

Within 2.5 years, AIDA has grown to over 20 people, with 70 per cent of them holding PhDs. It focussed its efforts in the financial services industry. Currently, it has Tier-1 banking and insurance customers in the region including Singapore, Malaysia, Indonesia and Hong Kong.

Its core products in insurance includes a health insurance claims Straight Through Processing (STP) system that was launched by a major insurer in Singapore in 2017. It has also developed an outlier/fraud detection engine which can shine light on the myriad of ways in which claimants or providers may defraud the system. AIDA's core products in banking include a Know Your Trader (KYT) Platform which can be used to detect trading floor misconduct.

Its uniqueness is the holistic view it provides of both the structured and unstructured data by using a combination of supervised and unsupervised machine learning algorithms. AIDA has recently completed its Series A round led by Mastercard, supported by SGInnovate and Kuok Ventures.

This startup is an example of computer scientists who have experienced some success turning their research into market-ready products.

Case Study 3:

Unum Therapeutics: Relocated to US due to lack of facilities and funding

Dr Dario Campana has three startups under his belt. A recognised authority in immunotherapy for cancer, his research has led to new products designed to harness the power of a patient's immune system to cure cancer.

His startups were founded in 2014, 2015 and 2016. In 2011, Dr Campana relocated to the National University of Singapore (NUS) from the US. In 2014, veteran pharmaceutical executive Charles Wilson flew to Singapore to meet Dr Campana after reading about his research. After two days of discussion, Unum Therapeutics was born. It would use the special antibody-coupled T-cell receptor technology discovered by Dr Campana to fight cancer.

Wilson would be the CEO while Dr Campana would be the scientific advisor. Challenges began from the start. There were obstacles to commercialise the research here. There were no life sciences incubator or accelerator in 2014, with the necessary laboratory equipment to turn the research into a product. To buy such equipment would have been expensive, exhausting whatever initial funding that would be raised.

No venture capital firm was also interested in funding the research. They viewed the venture as risky. It would also take too long to recover their investment because of the long gestation period to develop a product for sales. Besides, big cheques were absent in Singapore to fund the translational research. Unum then started in Cambridge, Massachusetts.

In 2018, Unum which has several ongoing FDA-approved clinical trials, was listed in Nasdaq raising about US$69 million. It has also received a US patent for its product covering antibody-coupled T-cell receptors. Nkarta, Dr Campana's second startup was also based in the US for similar reasons but his latest company Medisix Therapeutics is based in Singapore.

He feels the ecosystem in Singapore has improved with the availability of life sciences incubators, and investors with an increasing appetite for disruptive deep technologies.

Dr Dario Campana, Scientific Advisor of Unum Therapeutics

4.

RISKS AND REWARDS

The potential of real, defensible discoveries and technologies, paired with a smart business model, is a compelling proposition for the investment community, especially when these discoveries are often based on monopoly-forming technology, leaving a lasting impact on people and society. Yet founders and investors today remain cautious about the Deep Tech sector.

The primary risk is evaluation, the ability to understand the scientific discovery for which one needs technical competence.

Investor competency in the physical and biological sciences and engineering or all of them are necessary so that the question "is this discovery for real or is it science fiction?" need not be asked. Once there is understanding and expertise, the next issue will be: is there a real problem for the scientific discovery to solve? If yes, then there is a chance it can be turned into a business.

Deep Tech investments are tricky due to its long time to market availability. Not only is there a technical and implementation risk, there is also the peril that the market may no longer be there when the product is ready to be launched.

Investing in startups especially in Deep Tech companies is not for the faint-hearted. Investors must open their purses. Large cheques of tens or hundreds of millions of dollars are not unheard of. They are vital to pay for among other things, scientific talent, product research, lab equipment and facilities and clinical trials.

Investors have to understand these factors to make a good investment evaluation. A further quality needed is that of "patient" capital, because Deep Tech is a longer road to liquidity.

The financial reward is return on investments. This can be upwards of 10 to a 100 or more times the investment when a startup gets a public listing or is acquired.

A more satisfying reward is that the Deep Tech product or service advances mankind and has a profound impact on people's lives, society or industry.

How to evaluate a Deep Tech startup?

Scientists who transit into successful entrepreneurs are rare. Therein lies the challenge. One approach is to ensure that there is an experienced corporate executive who will run the business and operations. The corporate executive must also have the domain knowledge, for example, a senior pharmaceutical executive would be best suited for a startup commercialising a cancer-killing drug.

Singapore-based organisation SGInnovate, advises that investors take a multi-pronged approach.

> **"Technological superiority and the immediate total addressable market are two key considerations. Others include the alternative approaches to the problem; engineering challenge needed to productise and manufacture the new product or solution; the common purpose of the founding team to last the distance; the regulatory hurdles; and the state of the market trend."**
>
> **Hsien-Hui Tong**
> *Head of Venture Investing, SGInnovate*

SGInnovate's advantage is that it can bounce concepts off senior corporate leaders, government officials and world-renowned scientists to get a clearer picture of where a particular technology and/or market is moving, allowing for better investment decisions. It is also set up to support Deep Tech companies which may need regular guidance to achieve their milestones so that future funding can allow them to hire professional managers, thus allowing the original founder to take on a more technical or R&D role.

For individual investors including family offices interested in investing in such startups, it would be advantageous to partner with VCs because they have the dealflow and the evaluation methodology to identify the Deep Tech startups most likely to succeed.

5.

OPPORTUNITIES TO INVEST

Urbanisation and digitalisation trends pose new challenges for governments. Providing affordable healthcare, efficient transportation and relieving urban congestion are the issues which can be solved by hard core science and engineering. Opportunities are opening up in various industries including medtech, quantum technology, Internet of Things or connected devices, artificial intelligence and autonomous vehicles. These are the growth areas, some of which are highlighted below, in the next 5 to 10 years.

Medical technology

Healthcare demand already outstrips supply in the Asia-Pacific region which has over half of the world's population. Access to modern medical technologies will rise with increases in income, population and general awareness of health issues.

The medtech market will hit US$133 billion[9] by 2020. Wearables to measure and monitor vital signs, cancer fighting drugs and new medical intervention techniques are among the potential areas for scientific discovery and innovations.

Cancers are among the leading causes of mortality worldwide, with approximately 14 million new cases and 8.2 million cancer-related deaths in 2012. The cancer treatment market alone is a US$895 billion annual global spend.

New immune oncology agents that leverage the body's immune system to augment traditional therapies like chemotherapy and radiation, offer cancer patients new hope, creating a panoply of investment opportunities.

Quantum technology

Quantum technology is about sub-atomic physics. In a sense, the technology has existed for 50 years[10], in areas like nuclear power or the semiconductors in PCs and phones. Wider commercial applications have cropped up because now scientists can understand and control the inner workings of atoms more closely. Quantum technology is able to handle more data faster. It offers more secure communications, tamper-proof navigation and timing systems and is more reliable. Hence its use is widely expected in cryptography, pharmaceuticals, financial services and artificial intelligence.

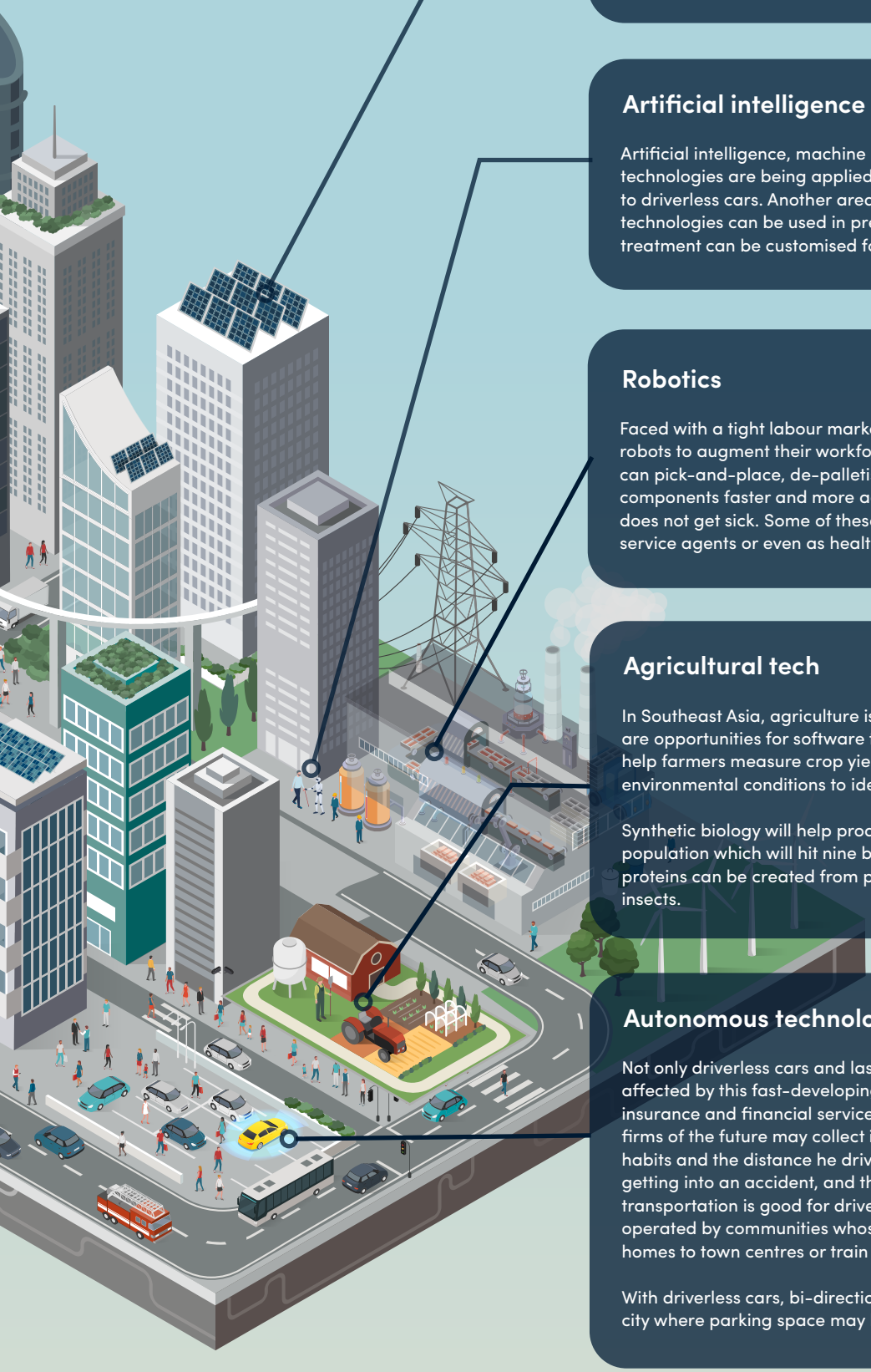
Internet of Things

Internet of Things or connected devices are expected to more than double between 2017 and 2020. Companies can analyse the data collected and multiplied from all these devices in real time to generate innovative new services. As the market shifts from connectivity to platforms, applications and services, IoT will become a trillion dollar[11] opportunity.

[9] Meeting growing Asia-Pacific demand for medical technology
https://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/meeting-growing-asia-pacific-demand-for-medical-technology

[10] Taking the quantum leap: What is quantum technology for business?
https://www.computerweekly.com/opinion/Taking-the-quantum-leap-What-is-quantum-technology-for-business

[11] New GSMA study: Operators must look behind connectivity to increase share of US$1.1 trillion IoT revenue opportunity
https://www.gsma.com/newsroom/press-release/new-gsma-study-operators-must-look-beyond-connectivity-to-increase-share/



Renewable energy

Climate change is upon us. Carbon emissions, rising sea levels and the climb in global temperatures have to be managed. One area for investment is energy storage which is critical for balancing power supply and electricity demand for homes.

Artificial intelligence

Artificial intelligence, machine learning and deep learning technologies are being applied in different areas from cybersecurity to driverless cars. Another area is healthcare where these technologies can be used in precision medicine where medical treatment can be customised for individuals.

Robotics

Faced with a tight labour market, small manufacturers can turn to robots to augment their workforce. Armed with machine vision, they can pick-and-place, de-palletise, assemble or package tiny components faster and more accurately than a human worker. And it does not get sick. Some of these robots can be used as customer service agents or even as healthcare providers.

Agricultural tech

In Southeast Asia, agriculture is a big part of some economies. There are opportunities for software to be embedded in farming tools to help farmers measure crop yield, or to collect data from farms and environmental conditions to identify the best timing for planting.

Synthetic biology will help produce more food for the world's population which will hit nine billion by about 2030. Alternative proteins can be created from plant-based substitutes and edible insects.

Autonomous technology

Not only driverless cars and last mile public transport systems will be affected by this fast-developing field. Adjacent industries such as insurance and financial services will be impacted too. Insurance firms of the future may collect information on a driver's driving habits and the distance he drives to ascertain the chance of him getting into an accident, and thus the premium he will pay. Last mile transportation is good for driverless mini-buses that can be operated by communities whose residents want to move from their homes to town centres or train stations.

With driverless cars, bi-directional cars will be good for use in the city where parking space may be smaller and tighter.

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INSIGHTS

These insights are drawn from the research undertaken for this Insights Paper. They are also pertinent to Singapore as it pursues an innovation-led future economy.

Funding

No good projects, no big funds. It is a chicken and egg problem.

Larger funding sizes upwards of S$5 million (US$3.6 million) are required by Deep Tech startups to pay for researchers and scientists and the long duration needed for customer tests and clinical trials. The funding is unlikely to come from angel investors unless they are subject matter experts or they are able to make informed evaluations.

Southeast Asian projects are likely to be funded out of Singapore. Funding is likely to come from the existing VCs with offices in Singapore since 2010s like Jungle Ventures, Golden Gate Ventures and Monk's Hill Ventures. Having raised bigger funds of US$50 million to US$200 million and beyond, they may want to diversify their portfolio to include the Deep Tech startups. However, they are still more comfortable with ICT technologies, veering towards AI, machine learning/deep learning and software as a service.

The good news is that there are a handful of new VCs like Lightstone Ventures which has a Singapore-based US$50 million life sciences fund. State-owned investment company Temasek Holdings has also set up special groups to explore investments in AI and blockchain.

Still missing is the US$1 billion fund that will signal clearly and loudly to the investment community that there are benefits from investing in the Deep Tech sector. Governments including Singapore, is best placed to set up such a fund.

Licensing

Technology licensing can be tedious and cumbersome. Simplify the process and maybe more projects will fill the pipeline. Roger Yuen, serial entrepreneur and Chairman of ViSenze, a visual search company, suggested the focus of licensing should be about the feasibility of the patent being turned into a product, not about the price of licensing the technology.

Talent

Negotiations on licensing can often break down over costs. Patent owners want the best price for their work. Entrepreneurs want a technology that can be turned into a product instantly to generate revenue. Focussing on commercial feasibility is a way of overcoming one hurdle in technology licensing.

It is a case of "monkey see, monkey do." Dr Campana, Dr Wong and others can become role models for the scientific community and encourage scientists, researchers and doctors to spin out their ideas, discoveries and innovations. They become the scientific advisors, leaving the entrepreneurs to run the business.

An innovative way to solve this problem is a "body shop" concept set up in Canada to develop AI technologies for companies who do not have the resources. Yoshio Bengio, a well-known Canadian computer scientist, was frustrated that he could not fill postdoctoral positions in his lab. He got together with serial entrepreneur Jean-François Gagné to found Element AI to develop tools and solutions for companies who do not have access to resources and AI talent.

AI researchers get the best of both worlds. Computer scientists and AI experts work for Element AI for several hours a month yet keep their academic positions. This way businesses would get top talent while the universities get to keep their researchers.

Singapore is no stranger to this concept. It has many applied research agencies like the Institute of High Performance Computing which undertakes applied research to help enterprises solve their business problems. Might it not be possible to follow the Element AI model by commercialising one of these agencies?

Partner, matchmake, co-create

One way to reach out to potential business co-founders is to network with the industry where there are many seasoned executives with good business acumen.

Research institutes and universities are already setting aside industry days and holding networking sessions with the private sector. These efforts can be stepped up to matchmake the scientists with the entrepreneurs.

Encouraging co-creation within research institutes and universities is another way like the NUS Grip initiative. NUS puts up a S$25

million (US$18.1 million) fund to get graduates, post-doctoral fellows and research staff to come together to set up their own Deep Tech startups.

The Hongkong Science and Technology Park (HKSTP) has a simple strategy to assist their startups. It invites Hong Kong's large corporations like MTR Corporation, Cathay Pacific, PCCW and Cheung Kong Holdings to their startups' pitching sessions, not to get their money. It is to get their collaboration with the startups so that the latter can trial and test their innovations.

Companies and startups stand to benefit from this collaboration. Companies get access to talent and innovations, startups obtain direct industry knowledge – and maybe steal an executive or two – which would help them in business and product development.

Make a bet

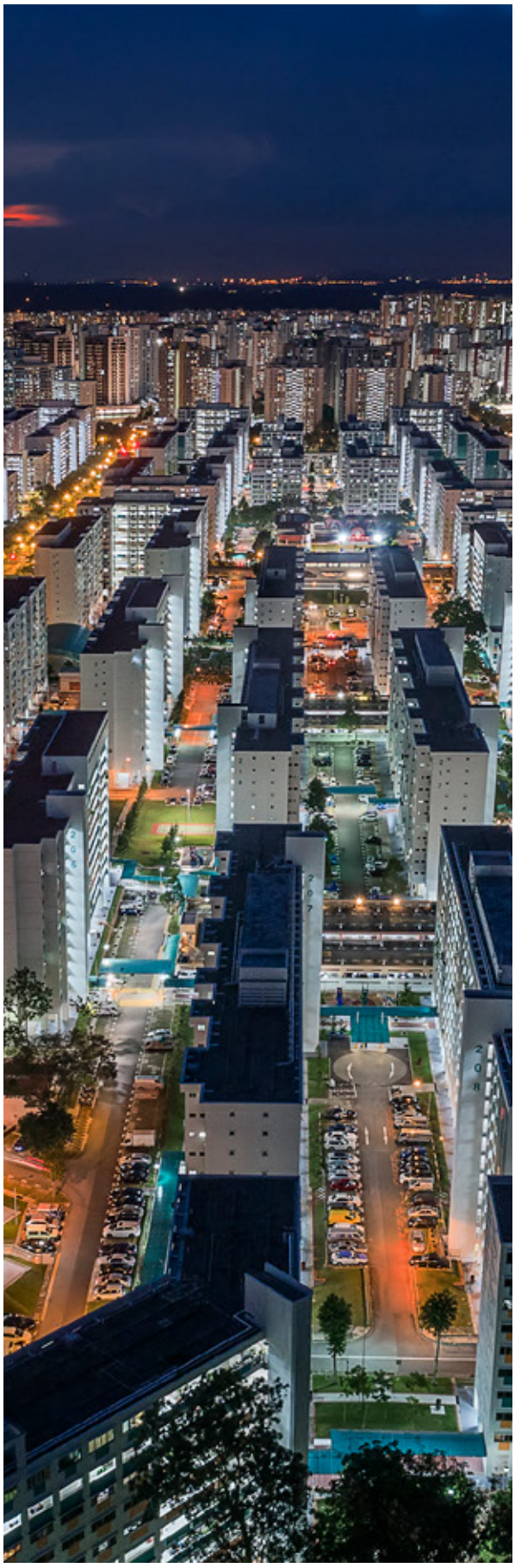
Many countries have invested billions in R&D. In 2018, Thailand unveiled a US$5 billion science and technology plan. Japan ploughed US$107 billion in R&D in fiscal year 2017. Singapore as a smaller country has had smaller investments. Over 24 years since its first National Technology Plan in 1995, the Government has invested about S$60 billion (USD$43.3 billion) in R&D.

In Singapore, the funds were spent "planting" the seeds. But what "crops" have been harvested? Step back in time for a bit here. In the initial years of the Republic's economic development, the R&D spending and research institutes were set up to support Singapore's foreign direct investment strategy. To attract the MNCs like HP, Seagate, Novartis and GE to locate their offices here, one way was to help defray their costs of R&D. In the process, Singapore benefitted as it created high value jobs for citizens and residents.

However, the new discoveries that were patented were mostly held by the MNCs and commercialised overseas.

Back to today, the "planting" is accompanied by much "watering and fertilising" to nurture the growth, but there is still no "harvesting". To harvest, it requires making bets on which startups will succeed. Perhaps there is a reluctance because of risk aversion, of making the wrong call, of fear of failure, of favouritism.

Dr Tan Geok Leng, CEO of AI startup AIDA Technologies and an industry veteran said: "We must identify the unpolished gems, the technologies, the people and the ideas that will make a difference."



Mine the patents

Identifying the patent gap for specific technologies is a good way for investors to evaluate the Deep Tech innovations.

For the scientists and researchers, understanding what patents and IP have been developed is a strategy to direct their research to untapped areas.

Some IP databases already exist to guide investors, policy makers and entrepreneurs to do this. Global companies are already checking these IP databases. Singapore's Deep Tech startups can do the same. They do not have to look far.

Patsnap is a Singapore patent search startup. It has collected a huge repository of patents and is helping global companies, among other things, discover technological opportunities. Is there a gap, for instance, in autonomous technology that can be plugged by Singapore startups?

arXiv is one of the largest open-source databases of scientific papers. It can be used to download all the abstracts available, for example, in AI or autonomous technology. The key words can be tracked from 1993, showing shifts in technology trends which can direct or influence new innovations.

One of Singapore's most well-known consumer electronics company is Creative Technology. It is probably the only local company in Singapore that owns about 100 patents.

This company may not be the shining star it was when it first listed on Nasdaq in 1992 as the world's best sound card maker in the world, but it has the most comprehensive sound, graphics and media IP in the world. Sound is becoming sexy again with audio and "hearables" becoming tech's next big thing. Creative has the necessary IP stack in this domain. Can Creative's IP be married with other Deep Tech innovations developed in Singapore to give rise to a new product?

Greater research focus required

Nations around the world have complex R&D structures. Universities and large companies carry out R&D activities. There are also large national research labs focussing on areas which usually require substantial investments like the Oak Ridge National Laboratory[12] which has a budget of US$1.4 billion.

Singapore is the same. A small country will be nimbler by having greater clarity and focus in its R&D strategy. Early R&D efforts have led to capability development in several areas like microelectronics, manufacturing and IT. Going forward, focussing on key areas critical to the Republic's future would be constructive.

Dr Lily Chan, ex-CEO of NUS Enterprise highlighted the Government's efforts to ensure the security of food supplies. It is investing in the agri-technology sector over the next few years to bring together high-tech farming and R&D activities in areas such as indoor plant factories and animal feed production facilities. Similar strategies can be drawn up for chronic diseases like diabetes.

[12] Oak Ridge National Laboratory, https://www.ornl.gov/content/solving-big-problems

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CONCLUSION

Deep Tech is changing the world. There is now a global tussle in AI and life sciences, and for hard core scientific and research talent. For countries aiming to develop their own Deep Tech sectors, there needs to be a concerted effort to improve the ecosystem further. Bigger Deep Tech ideas pipeline and larger funds are needed.

For Singapore, it needs to strengthen and enhance the initiatives and programmes that have been developed so far.

Edwin Chow, Assistant CEO, Innovation and Enterprise, Enterprise Singapore, said: "The next phase of growth is outside of Singapore. It is no longer just about the ecosystem here, but how to help scale our startups quickly and go global. We should look through the perspective of what organisations need, and what they are prepared to pay. Use that to pull the innovations out of Singapore companies and labs into the global market."

There also needs to be a revolution and evangelism.

Revolution to get people thinking out of the box, to do things differently and to start thinking about "harvesting" the hardcore science and research, and to identify startups with technologies that are likely to succeed and nurture them well.

The IP licensing landscape can do with a transformation. For a start, simplify the way IP licences are granted across the research and university communities, making it easier for entrepreneurs and investors to access and use.

Evangelism is about championing the cause, spreading the word and making the impassioned speeches needed to get more scientists interested in turning their discoveries and innovations into Deep Tech. Widen the pool of potential investors too. Singapore has more than 180,000 millionaires[13] many of whom bank with wealth management units. They form a ready pool of investors, some of whom may be excited enough by the Deep Tech opportunities to invest in them.

The timing is right. There is great respect for hard core science and engineering to solve big societal problems. Opportunities are abundant and becoming available. It is now about harvesting those opportunities.

[13] There are 183,737 millionaires in Singapore, and 1,000 who are 'crazy rich'" Credit Suisse. Oct 18, 2018,The Business Times https://www.straitstimes.com/business/economy/number-of-millionaires-in-singapore-up-11-to-183737-in-year-to-mid-2018-credit


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