DEEP SCIENCE FOR DEEP IMPACT

An overview of scientific initiatives that can transform India

YOURSTORY

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Foreword

Shradha Sharma
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A gel that stops bleeding. Brain implants that help people recover from brain damage caused by strokes. Organs that can be 3D-printed on demand. A breakthrough in the growing resistance to antibiotics. To the average person, these might seem like science fiction. They're not. These and other equally wondrous solutions are real, and on the cusp of becoming a part of our daily life.

And many of these are being developed right here in India. Some have already been deployed worldwide.

I had heard of Deep Tech startups a couple of years ago – they need far more investment than they're getting right now. The same applies to Deep Science. But the situation is so much better than it was a few years ago. When we started putting together this report on the state of the Deep Science startup ecosystem in India, we wondered if enough was being done to support it.

As we dug deeper, we realised that 'enough' is a relative term. Deep Science requires patient investment and cutting-edge infrastructure and equipment. It needs the right support system to innovate, experiment, test, deploy or go back to the drawing board, if needed. Some of these solutions are treatments, which means they need to go into clinical trials, so their time-to-market is quite long.

As we dug deeper, we also realised that India has the infrastructure – and some of it remains unused. We also realised that there is a new breed of investors who are passionate about seeing these ideas succeed and are patient enough to see them through to commercial deployment. The government too is an active participant in providing the type of support that only governments can.

And we realised that there are stories here that need to be told. Stories of the entrepreneurs and innovators who are trying to change the way things work and create a better society and a better life for us all. A better life for those who need it the most, because many of these solutions have the potential to help the most marginalised in our society.

As chroniclers of India's startup ecosystem, we discovered some amazing stories to tell and found that there are so many more still to be written about. This report is an introduction to the Deep Science startup ecosystem in India – what it is up to, what it needs, and where we are going with it. There is so much more to discover and talk about, and we plan to do that through our online platform. This report is just the beginning of a series on telling the best stories from India's Deep Science ecosystem.

Introduction

Nisha Holla
Consulting Editor &
Primary Contributor

Headlines today generally revolve around India's intense economic growth (formidable), India's flourishing tech startup ecosystem (admirable), and global and local politics (perennial). What we hear little of, and regrettably so, is the tireless work that thousands of scientists, researchers and engineers do in small pockets across the country in the many fields of fundamental innovation. With this report, the YourStory team is pioneering coverage of deep science innovation in India.

Deep science innovation is hard to define, to explain, and to classify. By its very nature, each innovation changes the playing field irreversibly and across complex dimensions. In this report, we have attempted to define and explain innovation of this kind because we truly believe it is important for everyone in India - especially the non-scientific citizen - to understand the transformation our country is experiencing in these hitherto obscure fields. The innovations being worked on by India's premier scientists and engineers have game-changing implications for the economy and for India's place on the world stage. Every Indian must be invested.

In this report, we have endeavoured to break down why deep science innovation is important for our economic growth. We have presented an in-depth study of what India's many institutions, both public and private, are working on. From various arms of the government and government-backed institutions incentivising innovation to several private individuals/firms who are putting capital behind this. From sophisticated incubators providing space and equipment for entrepreneurs to tinker and perfect their innovation to academic institutions recognising the importance of innovation and building incubation arms to support their professors and students. And most importantly, startup entrepreneurs who have chosen to put time, effort and capital behind innovation journeys that take a long time to realise returns. It truly takes a village.

Unlike tech-enabled startups that have defined India's story so far, deep science startups take more time to realise returns due to extended build and test cycles, and longer go-to-market horizons. For this reason, capital and visibility have been slower to follow. But all that is changing now. India is home to pathbreaking innovation, and this report covers only the tip of the iceberg.

Personally, as a chemical engineer and physicist, I am very excited that Shradha and the YourStory team are giving deep science a powerful platform. As pioneers in disruptive media, once again they are demonstrating their passion for making sure every Indian knows what's changing in their country.

Onward!

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What is Deep Science innovation?

Any innovation that utilises fundamental scientific principles like chemical structures, behaviour of organisms big and small, diffusion of molecules in a medium, propagation of sound waves in the air, and so on - to make non-obvious changes in existing paradigms can be characterised as a deep science innovation. Breakthroughs of this kind generally have a big impact on society and policy.

Our everyday world is filled with examples of deep science innovations in the past. Today, we walk around with powerful computing devices in our pockets - our phones and laptops. Prior to 1958, computers were as large as rooms and unable to perform even one-millionth of the computations our phone is able to today.

A key innovation that made this possible was the integrated circuit, designed by Jack Kilby. His ingenious solution was to manufacture all circuit components on one piece of a silicon substrate, which unlocked a new paradigm in electronic miniaturisation. Pacemakers, hearing devices, medical diagnostic devices, solar heaters, GPS - the integrated circuit has made all our lives more comfortable.

Similarly, transportation was revolutionised by the invention of the internal combustion engine in the 1800s. Before this, travel was limited to walking or animal muscle over very short distances. The concept behind the IC engine is the expansion of liquids or gases in a high-temperature combustion chamber, thus producing lots of energy that is utilised for the movement of the vehicle. This innovation was made possible by a string of prior inventions like the steam engine, liquid fuel combinations, electric spark plugs, and so on.

Today, travel by car or aeroplane is ubiquitous and we take the ability to travel around the world in a day for granted.

Deep science innovation often constitutes a substantial amount of research and development, very long testing and validation cycles, and an extensive generation of intellectual property (IP) that contributes to the embedded value of the technology, product(s), and therefore, the company.

The stakeholders involved - entrepreneurs, researchers, and scientific advisors - usually come from highly technical backgrounds in fields like biology, chemistry, physics, applied mathematics, fundamental engineering like aerospace, chemical, mechanical, electrical, and so on.

What does Deep Science innovation focus on?

Deep Science innovation generally provides step-function solutions to situations and challenges which have so far not been addressed. Left unsolved, these challenges will continue to take a socio-economic and monetary toll on society or create massive problems in life and society if left unmitigated.

Development of preventive health measures like vaccinations is a great example. Microbial infections like the plague have historically wiped out large sections of populations. The development of vaccines for smallpox and polio have not only saved millions of lives but also saved capital that would have otherwise been spent on reacting to the infection and providing palliative care. It is estimated that the polio vaccine has created a net savings of $27 billion.

Innovations of this kind are expansive and open up new possibilities, market segments, and industries. Today, transportation is dominated by petroleum-fuelled vehicles and is a major contributor to environmental pollution due to the dependency on fossil fuels.

Electric cars with zero emissions and fewer moving parts are a great alternative, but their usage is restricted because the range afforded by the technology is much lower than petrol and diesel cars. Recent breakthroughs in lithium-ion battery technology have renewed interest in electric cars because of the numerous advantages they afford, like high energy density and low maintenance compared to other battery technologies.

Li-ion battery technology is opening up new markets for electric vehicles as well as new supply chain industries for EV parts and infrastructure like charging stations. Electric vehicles, in turn, are paving the way for breakthrough innovation in autonomous vehicles, which are easier to design and manufacture with batteries rather than the internal combustion engine. This is a great example of how deep science innovation is expansive and is creating a chain effect in opening up new market segments.

Where does deep science make the most impact?

Industries that are most impacted by deep science innovation are healthcare and biotechnology, clean energy, robotics, environmental engineering, manufacturing, food processing, agriculture, semiconductors and hardware, aerospace, and transportation.

These are sectors that deeply impact people's lives and the environment and are often crucial to our sustainable survival.

Is Deep Science the same as Deep Tech?

Yes and no. The term Deep Science is often used synonymously with Deep Tech. The similarity between the two is that both look at fundamentally changing a paradigm. However, one does so in the field of pure sciences whereas the other focusses largely on technology.

Having said that, the two do converge in intersectional spaces where a combination of hardware and software may be used to change a scientific process.

To be precise, Deep Tech is an umbrella term that sometimes refers to higher order innovation in computer systems and applied engineering, driven by increased computing capacity and the continuous utilisation of complex mathematical tools to unlock new ways of deepening machine intelligence. Artificial intelligence, machine learning, deep learning, artificial neural networks, image processing and data analytics are all examples of this innovation.

Significant breakthroughs are also taking place with the coupling of deep science innovation and deep technology. One example is the application of machine learning techniques and computational chemistry to design next-generation drugs, reducing the need for a big laboratory setup and manual experimentation techniques that take longer and are more prone to human error.

In this report, we focus on innovation in the fundamental areas of science and engineering with a marked focus on the difference that artificial intelligence (AI) makes. In other words, innovation that has the potential to change lives at a civilizational scale and drive India's sustainable development forward.

Why is Deep Science innovation important for India's economic growth?

How a country invests in scientific and technological development is a crucial component of its socio-economic growth. To look at how this plays out, let's examine scientific innovation cycles in the last two hundred years. Innovation cycles mostly emerged from the four industrial revolutions with hundreds of inventions that made a great impact on human life.

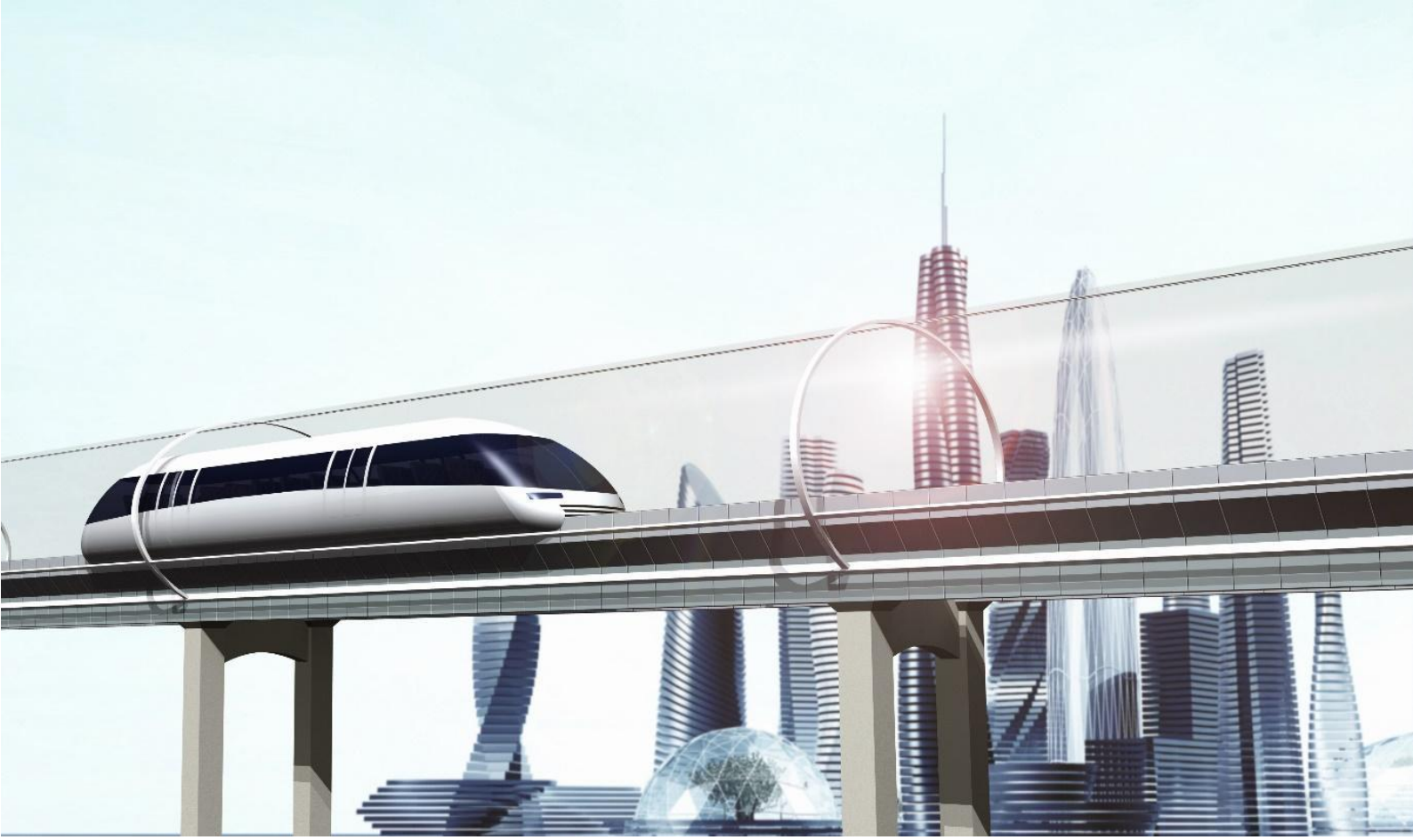
At the end of the 18th century, **the invention of the steam engine spearheaded the First Industrial Revolution in Britain.** The technology enabled a big jump in the mechanisation of production of goods, prior to which everything was handmade and hence, time-consuming. This productivity boosts catapulted Britain to the top of the world's economic leadership board for more than a century. Important technological inventions like the spinning jenny and power loom, combustion engine, and communication methods like the telegraph and the radio are the hallmarks of this Industrial Revolution.

At the dawn of the twentieth century came the World Wars, **the Second Industrial Revolution and a race to further improve productivity toward world dominance.** While both the United States and Germany invested heavily in technology development, with key deep science innovations like the atomic bomb, superior antibiotics and assembly-line process, the United States became the new economic leader in the world and continues to be a top economy today.

The US has continuously invested heavily in deep science. Both the private sector and the government through DARPA, DEA, etc are global players in R&D. **The Third Industrial Revolution is widely acknowledged as having begun in Silicon Valley, California, with the transistor revolution** and many US players are leading chip design and semiconductor equipment manufacturing companies. China, with the opening of its economy in 1978, realised the value of semiconductors early on and invested heavily in the fabrication industry. Two important consequences followed: (1) Today China dominates the semiconductor fabrication industry and has made it infeasible to manufacture chips anywhere else in the world in bulk, and (2) With careful study and design, the country is the second-biggest economy in the world competing with the US at every step.

We are currently in the midst of **Industrial Revolution 4.0, which is dominated by artificial intelligence, supported by superior computing architectures and network effects**, which in turn can affect every other major industry because of the productivity boost it enables.

The US and China continue to invest heavily in key deep science innovation segments like healthcare, computing, defence, energy, and so on. In addition to economic growth, research and development in these areas often lead to significant social growth and improvement in the quality of life. This is clearly observed in China's growth, where despite the large population of 1.4 billion, high socio-economic



growth has transformed life through strategic investment in innovation.

India is showing significant promise economically with a growth rate of 8 percent. How we invest in deep science innovation, research and development and careful application of the same will be crucial to sustaining the growth rate. With a large population and a high growth rate also comes rapid urbanisation and unsustainable environment hazards, preventing which will require key scientific innovation.

Healthcare

Healthcare is, of course, a key impact area for deep science innovation. It constitutes the search for better cures for diseases, ways to improve well-being and longevity and always with more affordable cures. What are the large health challenges?

Healthcare sciences and technologies broadly fall under three categories: (1) preventive, (2) diagnostic, and (3) curative. Developing preventive technologies not only has the advantage of saving lives upfront but often also converts into large economic savings of funds that would have otherwise been sunk into reacting to disease epidemics and palliative care. Vaccines are a big example here. As mentioned earlier, it is estimated that the polio vaccine has resulted in $27 billion in net savings worldwide.

Next, if we are unable to prevent a disease, the capability to diagnose it quickly and administer the required cure is indispensable. It is crucial to develop accurate and fast diagnostics for microbial infections, cancer, etc. For infections, in particular, the world over, antibiotics are prescribed without knowing whether the infection is viral, bacterial or even fungal. This has led to antibiotic abuse and the rise of multidrug-resistant (MDR) organisms also known as superbugs. Developing quick diagnostic capabilities to inform us what an infection is, and which organism is causing it will enable accurate prescription and dosing of the required medicine.

In India especially, with a dearth of healthcare and diagnostic infrastructure outside Tier I and Tier II cities, affordable and remote diagnostic

> The application of ML techniques and computational chemistry to design next-generation drugs is reducing the need for a big laboratory setup and manual experimentation techniques which take longer and are more prone to human error.

capabilities will make a significant difference. Miniaturisation of devices is leading to lab-on-chip applications, which promise to change healthcare infrastructure strategies for rural healthcare. Moreover, with mobile and connectivity developing so rapidly, mobile diagnostics also looks very promising.

Curative technologies will see the largest impact of innovation. The development of new antibiotics, antivirals, antifungals, cancer medication, are ongoing and always find new frontiers. With the promise of stem cell therapies and genomics, personalised DNA medicine seems very real in the next decade. No longer will prescriptions come in one dose, one form. Therapeutics will be tailor-made for each person's constitution and disease. Aiding this is 3D printing of organic tissue - drug-disease testing, organ regeneration, etc

Transportation, energy, and construction

India’s GDP is growing at 8 percent per year accompanied by rapid urban spread and development. Using China as a benchmark, the same growth rate led to significant air and water pollution. This is already evident in India's large cities. Sustainable strategies and development in transportation technologies, energy use and generation, and construction can enable India to sustain the high economic growth rate without sacrificing our environment and natural ecosystems.

India has developed a sustainable plan to increase energy production from renewables like solar. In 2018, 23GW of power was harnessed through solar and the plan is to hit 100GW by 2022. Efficiency improvements can be accrued with the development of photovoltaics and better battery and capacitor technology.

Today, five to six cities in India are taking the brunt of population increase and urban spread leading to a resource crunch. What we need is to develop a hundred cities around India with the latest water treatment facilities, public transportation entirely based on electric vehicle technology, renewable power production and the best infrastructure.

Buildings must be built with the latest in HVAC and cooling systems, green buildings, decentralised and integrated water management facilities, new architectures that allow more sunlight into the building. Material innovations like self-healing cement and others must be incorporated into buildings and bridges for longevity. In this manner, innovation can help bolster the Indian Government’s Smart City initiatives to create cities of the future.

Why it is important for India to invest in Deep Science today

It is often said that India has a multitude of problems. But when problems are viewed as opportunities, deep science can create a lot of value, which, in turn, can drive socio-economic growth.

As we stated earlier, innovation cycles have mostly emerged as the four industrial revolutions with hundreds of inventions that emerge from deep science and have made a great impact on human life. Today, explosive development is taking a toll on our lives and on our environment. Socioeconomic inequalities desperately need to be addressed. And none of this will be possible without deep science innovation.

So, what does deep science innovation need? Three things:

What we need is a continuous injection of ideas in deep science. For this, we need

- Smart people trained in science and engineering
- Interdisciplinary training programmes that teach people how to build quality products
- State-of-the-art research facilities and incubation centres where scientists and entrepreneurs have access to equipment and space to tinker, test and validate their ideas
- Incentives and support systems for these smart people to actualise their ideas

Deep investment strategies

Deep science innovation has very long runways, often requiring 10-15 years to actualise real returns. For this, patient capital from both private and government players is required. Optimising for long-term returns over short-term gains is a requisite. A great model here is the DARPA model – the Defense Advanced Research Projects Agency – in the US. DARPA started in 1958 as a response to Russia's unexpected success with Sputnik. In the 60 years since, DARPA has played a long investment game that has led to key, everyday technologies like the GPS, internet, imaging and camera systems, and continues to do so. DARPA's model for patient capital is exemplary and worth implementing in the Indian context.

Long-term vision

Now, if we have set up a good system for the proliferation of new ideas and deep investment strategies, then the third ingredient for success is a long-term vision, a targeted approach to each target industry and sub-industry, and then we work backwards. For example, India has already set a remarkable zero-emission target for 2030. Then we back-calculate what that means for investment in renewables, electric vehicles, maglev technology. For water, can we set a target of decreasing water wastage by 50 percent? How do we achieve that?

Vision is important, especially for deep science because it takes very long to see the results of the investment of time and money. In order to make the most of what we have and what we are

doing, it is also important to learn from the mistakes of others and not reinvent the wheel.

Here are examples that we would do well to bear in mind.

The US and antibiotics

Before the scientific understanding around antibiotic resistance could develop, the US flooded their food and water with antibiotics.

The human body contains sizeable populations of bacteria in the microbiome that are beneficial for our health. Antibiotics are strong medicines that kill multiple target bacteria, both good and bad. When the body is infected with harmful bacteria, the benefits of taking antibiotics usually outweighs the risks.

However, if antibiotics are taken unnecessarily, certain populations of beneficial bacteria get wiped out in the body leaving only the strains that are resistant to the antibiotic. These strains then multiply rapidly leading to huge populations of multidrug resistant bacteria or superbugs, as they are called now.

In the US, before the overuse of antibiotics was understood, antibiotics were introduced to farming to prevent bacterial infections in crops, and poultry and livestock.

Over the 50 years this has happened, most of the plant-based food, dairy products like milk, and meat now available in the US contain antibiotics. People are ingesting this food on a daily basis, so the number of superbug strains has been growing and getting stronger.

In January 2017, the US witnessed what was possibly the worst ever consequence of the overuse of antibiotics. A woman from the state of Nevada died of an incurable infection caused by a ‘nightmare superbug’ that was resistant to all 26 antibiotics available in the market.

> India must use its deep science research arm and capabilities to study scenarios in other countries and use the research to examine the long-term implications of any food and agriculture related changes.

The Centre for Disease Control in the US believes that over 20,00 people die each year from such drug-resistant infections. Globally, that number climbs to 700,000, either because the resistance is not discovered in time to be treated with a last-line drug or is expensive/unavailable.

India must use its deep science research arm and capabilities to study these scenarios in other countries and use the research to examine the long-term implications of any food and agriculture-related changes.

China and transportation

When China underwent rapid development at a very high economic growth rate (like India is now), they also indiscriminately installed coal-based energy plants everywhere. Rapid urbanisation also means personal vehicle consumption went through the roof, and still is. This is not unlike what happened in developed countries when they went through the same development cycle, except China has a very large population, which compounds the effect.

If people in China and India consume energy (and coal) the way industrialised nations do, our pollution problem compounds, as evident in China and in populated cities in India. China is the only country India can study and learn from in these matters because of the comparative populations.

India needs to import new technologies and train people to use technologies that are becoming crucial to future development.

What India did and can do

India did the right thing with transportation. It invited automobile manufacturers to set up assembly plants in India. A huge segment of the population is now exposed to the process of automobile manufacturing and deeply understands the need for leapfrog technologies like batteries and magnetic levitation.

India should have done the same thing with phones - set up manufacturing here. Now, it's a little too late. One billion phones in the country already, and we don't have a single indigenous phone manufacturer. We do have phones being assembled in India, but the brands are mostly Chinese.

India can follow the model China did with semiconductor fabrication. The market was dominated by the US, Germany and Japan until the 1990s. China sent its technologists all over the world to study the industry and came to the crucial conclusion that dominating the manufacturing pipeline was key to becoming the industry leader. Today, it is the most inviting destination for fabrication at scale.

India's IT entrepreneurs were able to harness the wave in 1990s to build some of the best IT services companies in the world. The same investment of resources is required in deep science. The focus should be on technologies that will become important in the future and invest in people who can develop these leapfrog opportunities. Areas with the potential for most impact in India include:

- Agriculture
- Energy
- Water resources
- Defence and aerospace
- Transportation
- Sustainable ecological and environmental engineering
- Artificial intelligence and machine learning
- Sewage treatment, plastics and waste management

Deep Science in Action

STARTUPS | INVESTMENTS

GOVERNMENT | POLICY

ACCELERATORS & INCUBATORS

Aarav Unmanned Systems: leading drone technology applications in India

Aarav Unmanned Systems has developed drones that can collect 3D images that are 10x sharper than what satellites provide and can provide crucial data and analytics to governments and industries that work in difficult terrains.

Unmanned aerial vehicles (UAVs), aka drones, no longer belong in the pages of speculative fiction; they are here and now and have practical use cases in agriculture, disaster management, photography, and land surveying. Drones have made it possible to get high-quality images and videos that can throw light on a lot of issues. And a few Indian startups are already using this technology to solve problems.

Aarav Unmanned Systems (AUS) is one such drone tech startup. It was founded in 2013 by **Vipul Singh, Nikhil Upadhye, Suhas Banshiwala and Yeshwanth Reddy.** The company came about after Nikhil and Vipul represented IIT Kanpur, at the SAE Aerodesign competition organised by NASA in 2013, during which they had to create a UAV with a specific weight and payload. This competition made them realise how India is in the dark when it came to UAVs and its extensive use for enterprise applications. They were soon joined by Suhas and Yeshwanth Reddy, who like them, took an interest in robotics and aero-modelling.

Today, Aarav's commercial-grade drones provide solutions across in disaster relief, mining, urban and rural planning, surface transport (roads and railways), as well as agriculture and irrigation.

How it works

Photogrammetry is the science of measuring distances between objects in a picture. UAVs, which run on this science, render information about the topography of a stretch of land, which is usually collated by engineers. However, this information can be translated into simpler terms with the help of multiple colour codes, coordinate values and feature identification to signify the quality and terrain of the land.

AUS drones have unique features that set it apart from competitors. The UAVs can geo-tag the areas using it is in-house PPK-GPS technology without or limited markers on the ground called GCPs (ground control points). The horizontal and vertical accuracy of up to five centimetres allows the user to obtain instant images with survey quality data. The operation is completely autonomous and does not require any kind of manual intervention.

Apart from new products/solutions in the pipeline, AUS's flagship products include:

Insight-PPK which weighs about 3.4 kg: It has a payload of 400gm and has a range of two km. Its endurance is about 35 minutes which enables it to cover 40-hectare area per flight at 4 cm/pixel resolution.

AUS's fully autonomous drones capture detailed 3D models of the areas they scan. They are also able to scan larger swathes of areas in a single day. Use cases include mapping of mines, forest cover, search and rescue operations, and

damage assessment after disaster relief, as well as property mapping for tax assessments.

When it comes to mapping and survey, these drones provide 30 million data points per square km with 5cm horizontal and 7cm absolute vertical accuracies, 98 percent volumetric measurement accuracy, and 100 percent support in importing the direct outputs to AutoCAD, ArcGIS, Minex, Surpac, etc, technologies used for planning, design rendering.

The precision agriculture software provides data on the plant health analysis, yield monitoring, chlorophyll indication, nitrogen recommendation, and plant stress assessment. Insight also has an industrial inspection feature that provides information with its thermal accuracy and thermal maps.

So far, AUS has mapped more than 1.7 lakh acres of the area over last 18 months for different applications across India which includes mapping almost 250 villages in Rajasthan in just 60 days to aid watershed development to help farmers get more underground water and conserve the fertile topsoil. Simultaneously, AUS has been instrumental in making policy recommendations to the government to help achieve a conducive ecosystem for mostly startup driven drone industry in India.

Growth plans and what's next

AUS, which aims to be an end-to-end provider and not just a regular UAV, says it provides faster and more cost-effective land surveying solutions than its competitors. It recently worked with the Kerala government to ascertain the damage caused by floods in 2018 and has already mapped out large parts of Rajasthan and Maharashtra while working with their local governments. It has also mapped out mines in Telangana, Rajasthan, Chhattisgarh, etc. Its private sector clients include conglomerates like Aditya Birla Group, Larsen & Toubro, the JSW Group, Vedanta, and the Adani group.

AUS has raised an undisclosed round of funding from a group of investors, including 3One4Capital, StartupXseed, GrowX Ventures, Auxano resources, 500 Startups, and angel investors Ashok Atluri and Sanjay Jesrani. It is reportedly in talks to raise Series A funding.

AlphaICs: a superchip for artificial intelligence, from India, for the world

AlphaICs is looking to revolutionise automation by developing developer-friendly processors with wide ranging application in drones, robots, autonomous vehicles, Internet of Things, analytics, and more.

Artificial Intelligence (AI) workloads require enormous amounts of power to compute. This is largely because of the petabytes of data that needs crunching. (One petabyte is equal to 1 million gigabytes!) Today, be it at a data centre or an edge computing device, companies are looking for an ace chip that can, with the least amount of energy, compute data within milliseconds. This typically means the computing of data takes place in real time and there is information flow to the customer, which means the business or gratification value is generated instantly.

Take driverless cars, for instance, which need to take a decision on whether to brake or not. To make that decision, it needs to process a multitude of data in a fraction of a second, otherwise it might hit a pedestrian or a bike. The chip that AlphaICs is developing enables that.

A major player in the space, AlphaICs is a startup that makes custom processors that are developer-friendly to build algorithms for advanced applications. The company was founded by Nagendra Nagaraja along with Vinod Dham (aka the father of the Pentium processor) and Prashant Trivedi in 2016 in Bengaluru. Nagendra has 27 patents in his name in the field of AI and wireless security.

How it works

AlphaICs' Real Application Processor or RAP is an architecture that makes the 'agent' a basic compute element. Agents are defined as autonomous, problem-solving computational entities capable of operating interactively in dynamic heterogeneous environments.

Multiple agents interact and operate individually or in cooperation with other agents, with some degree of autonomy to achieve overarching objectives. "Agents represent the most important new paradigm for combining perception and decision making harmoniously in real life applications," says Nagendra.

Each agent is a 'group of Tensors' thus packing a whopping performance and enabling a high dimensional compute. These agents operate in a multi-agent environment for asynchronous processing of AI algorithms. This is the science behind AlphaICs' ability to crunch large data sets in real-time.

Think about all the work flows that you need to understand a biometric system, or a loyalty program filled with patterns across the world or something even more complex as connected vehicle drives or internet of things (IoT), the RAP systems support all machine learning (ML) frameworks, edge applications and data centres. Truly ground-breaking.

Growth and market fit

So far, two of the company's products have gone commercial and AlphaICs says it has clients from Japan as well. It competes with the likes of NVIDIA, Graphcore, Sambanova, Mythic and Syntiant. The company also has some marquee Indian investors in the form of 3one4

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Capital, Emerald Technology Ventures, Endiya Partners and Rebright Partners. AlphaICs has raised $3.5 million so far and expects to raise a multi-million-dollar round soon. The team currently comprises 25 people.

Use cases of AlphaICs

According to Nagendra, AlphaICs is currently looking at industrial automation, as well as robots, drones and cars. But beyond that, there are larger applications in healthcare and surveillance. We take a look at some use cases.

Streaming Data Analytics

Most of the connected devices produce streaming data. Generally, data is continuous and has temporal characteristics to it. The data becomes valuable when it is used to produce insights and decisions in almost real time. Streaming data is processed sequentially and incrementally to produce insights in real time. RAP processes small batches of data very efficiently with almost zero latency. Unlike all other solutions, which focus on alerts, **RAP™ provides actionable insights for streaming data through near-real-time decision-making.**

Search applications

Search is very important for online businesses. Be it search engine, an ecommerce website or a travel site, users want to get answers instantly and a good answer means a returning customer and a bad answer means a lost customer. Technology should be able to run small batches as waiting to make large batches means increasing latency for earlier users.

RAP's agent-based compute is very efficient with large and small batches. RAP architecture makes it ideal to accelerate conditional compute.

High performance computing

Genomics, life sciences, trading and weather forecasting applications need high performance computing for their operations. These workloads require high compute, parallelism and complex modelling. Some of these workloads require thousands of nodes to be connected. RAP's agent-based architecture provides huge parallelism with SIMA groups. Agents in these groups parallelise computations, run asynchronously and provide acceleration that is not possible with competitive solutions.

Business analytics

Businesses are constantly increasing customer engagements and evaluating customer responses for their campaigns. Globalisation has made business value chain very complex and complex financial tools require continuous monitoring. RAP has on-chip agents to expedite decision making. Furthermore, RAP's agent-based learning techniques can be used for text mining, and RAP-based dialogue systems effectively learn from user interactions. RAP can predict and optimise outcomes and simulate potential alternatives in a typical business setting.

These are data centre applications. RAP can also power drones, cars, industrial machines, robots and automate them. It can also power VR/AR headsets and wearables too.

Ather Energy: paving the way for sustainable personal transport

Ather Energy is developing vehicles for a time when we will have no fossil fuels to run on.

Every day, science has a new idea to help sustain what we have left of this planet. Our natural resources are finite and will deplete soon, and we need to look for alternatives.

Electric vehicles (EV) have helped adopt an eco-friendly way of travelling, saving on fossil fuels like petrol, diesel and natural gas. India has seen an array of EVs, including Reva, Mahindra's e2o, and even YO bykes.

However, Ather Energy says it differs from the rest. "It's not the way we manufacture vehicles that differentiates us, but the ownership experience that is enabled by the intelligent and connected features," says Swapnil Jain, Co-founder. "For example, OTA (over the air) helps us improve features on the go: better maps, improvements on core components, service becomes predictable and personalised to your vehicle," he adds.

Founded by IIT-Madras alumni Tarun Mehta and Swapnil Jain in 2013, the company manufactures electric scooters. High capacity for range, high power output for quick acceleration and speed, a long life and fast charging abilities are some of the features that they wanted in an EV, and since no existing models had the best of these, the duo decided to just build one on their own.

In early 2014, they received a funding of Rs 45 lakh from the Technology Development Board under the Department of Science and Technology, IIT Madras, and Srini V Srinivasan, a fellow IIT-Madras alumnus and founder of Aerospike. Later that year, Flipkart co-founders Sachin Bansal and Binny Bansal invested $1 million as seed capital.

The big deal about electric scooters

In India, public transportation is woefully inadequate. And where it's available, last-mile connectivity is a challenge. Much of this is covered by two-wheelers, whose sheer numbers contribute to consumption of fossil fuels and pollution. The only way out is to ensure two-wheelers use clean or renewable energy. And for now, that means electric vehicles (EVs). In fact, the government lowered the import tariffs on parts and components for EVs from 15-30 percent to 10-15 percent in order to promote emission-free mobility in the country. Earlier, the NITI Aayog had recommended that EVs should not incur road tax in order to make them more popular.

Ather Energy also created charging stations called AtherGrid.

Ather 340 and Ather 450 are priced at Rs 1.1 lakh and Rs 1.3 lakh, respectively. While the 340 model has a top speed of 70 kmph, the more advanced 450 model can travel at up to 80 kmph. Ather 340 is powered by a 4.4 kW motor offering 20 Nm torque and has an acceleration from 0 to 40 kmph in 5.1 seconds. Ather 450, on the other hand, gets its power from a 5.4 kW motor offering 20.5 Nm torque and has an acceleration from 0 to 40 kmph in 3.9 seconds. Both scooters get two drive modes – power and economy. Ather 340 delivers 60 km range in economy and 50 km in power mode. Ather 450

delivers range of 75 km and 60 km in economy and power mode, respectively.

However, the two models are similar in shape, size and design. Both scooters come with a charging cable, (home point for the 450 and a charging cable for the 340) standard installation and a one-year subscription plan for no additional cost.

Charging stations - Ather Points - are installed in different parts of the city and can be used to charge non-Ather EVs too. The company plans to set up AtherGrids – a network of Ather Points - everywhere including offices, malls, cafes, restaurants and gyms. Ather users can also use the Ather app to monitor the charging process.

Growth plans

Ather Energy has so far raised $59 million over four rounds of funding from the likes of Tiger Global and Indian two-wheeler giant Hero Motocorp for development, production, testing and launch of the vehicle.

It was in 2016 that the company unveiled its first EV S340 at a conference in Bengaluru. Soon after, Hero MotoCorp invested $30.5 million in Ather Energy for a 32.31 percent stake in the company.

The company is expected to soon set up about 60 grids at different points in Bengaluru. It recently confirmed that it was expanding to Pune and Chennai. The company also has plans to set up home charging points. For every Ather 450 that is delivered, the company sets up a charging point at the owner's home. It takes about 2 hours and 40 minutes to charge the vehicle to about 80 percent, and 4 hours and 18 minutes for 100 percent. To increase product understanding, educate customers about the vehicles, and provide pre-booked test rides, the company launched AtherSpace.

One can only hope that soon, more vehicle owners will start switching to sustainable options like the ones Ather Energy offers, leading to a healthy planet.

Bugworks: creating new drugs that fight Superbugs

Bengaluru-based Bugworks is renewing the fight against Superbugs by engineering antibiotics that combat the global threat of antimicrobial resistance – bacteria that have become resistant to antibiotics and cause infections that are difficult to cure.

Bugworks was started in 2014 by Dr Anand Anandkumar, Dr Santanu Datta and Dr Bala Subramanian, the latter two being veteran drug hunters from Astra-Zeneca India, to combat untreatable infectious diseases owing to antimicrobial resistance (AMR). AMR is growing at an alarming rate worldwide. In the US alone, the Centre for Disease Control (CDC) estimates that 1 in 25 patients will acquire an infection during their hospital stay and India is at the very epicentre of this crisis.

As Dr Anandkumar puts it, "Bugworks is solving a global problem that sees nearly 750,000 deaths per year, with India holding a lion's share of these mortality numbers, including about 100,000 babies we lose in India owing to neonatal sepsis."

What Bugworks has done is engineer a *new class of antibiotics* that target Gram-negative bacteria, which are the hardest to treat bacteria (also called 'Superbugs'). In today's world, a number of pathogens, specifically gram-negative bacteria, have developed resistance to most antibiotics. The drug efflux pump mechanism, which is highly developed in these resistant bacteria pushes out drug molecules from bacteria, effectively reducing the efficiency of the antibiotic.

The last known class of broad-spectrum antibiotics was discovered in the 1960s. Bugworks hunts for novel antibiotics to take down Superbugs. The company uses a proprietary platform called ELUDE, to design novel molecules that are able to evade the Efflux pump, almost invisible to the tough defence mechanism of the bacteria, just tricking it and killing it.

Bugworks' platform uses unprecedented modelling/simulation approaches juxtaposed with classical pharma practices to design these compounds that show broad-spectrum activity against superbugs. While big pharma companies have given up on the development of the new drugs to combat these Superbugs, Bugworks hopes to discover these life-changing antibiotics.

How it works

Traditional drug discovery processes, especially in large pharmaceutical companies, are

> Bugworks' USP lies in the platform technology they have built using a combination of expertise in infection biology, computational biology, computational chemistry, machine learning and pharmaceutical drug formulations.

From left: Bugworks founders Dr. Bala Subramanian, Dr. Shahul Hameed, Dr. Anand Anandkumar, and Dr. Santanu Datta

dependent on protracted trial-and-error laboratory methods. Bugworks is employing a vastly different approach - experts in infection biology map out methods in which drugs could kill bacteria. There are very few companies in this space, because the science is complex, and the economics is quite poor when compared to other areas in pharmaceuticals. The success rate in discovering novel broad-spectrum antibiotics has been abysmal, but Bugworks seems geared up to the challenge.

Bugworks' Novel Bacterial Topoisomerase Inhibitor (NBTI) is a breakthrough inhibitor that can target a broad range of drug-resistant bacteria and was designed by using their ELUDE platform. Bugworks' compounds enter the hard to penetrate bacteria, are near-invisible to the efflux pump mechanism and hit the bacteria in two target areas, causing the death of the pathogen.

The intersection of science and technology

Combining the powers of modelling, computational and structural biology and medicinal chemistry, the Bugworks team has been able to design an entirely new class of compounds that are showing exciting potency and safety characteristics at the preclinical level. Using the novel approach in science as well as a globally distributed execution model where they work with the best teams in the world, the company has been able to quickly progress their preclinical candidates.

The 20-member company is incubated within CCAMP and works with consultants and contractors from across the globe, in a truly 'virtual pharmaceutical model'.

Named GYROX, this is a new family of antibiotics is showing efficacy in various animal models against a wide range of superbugs, collected

from all over the world. The company is going through preclinical development and hopes to enter clinical trials by early 2020. Bugworks' lead products are also being tested against bacteria that could be used in Biological war or terror situation. So 'Biodefense' is another area of application for their products.

Apart from doing path-breaking science and creating new execution models to rapidly progress its compounds, the company is also collaborating with a number of research organisations like St John's Research Institute, Narayana Health, Tokyo Tech University, Instem Bangalore and Hope Laboratory Liverpool.

What's so special?

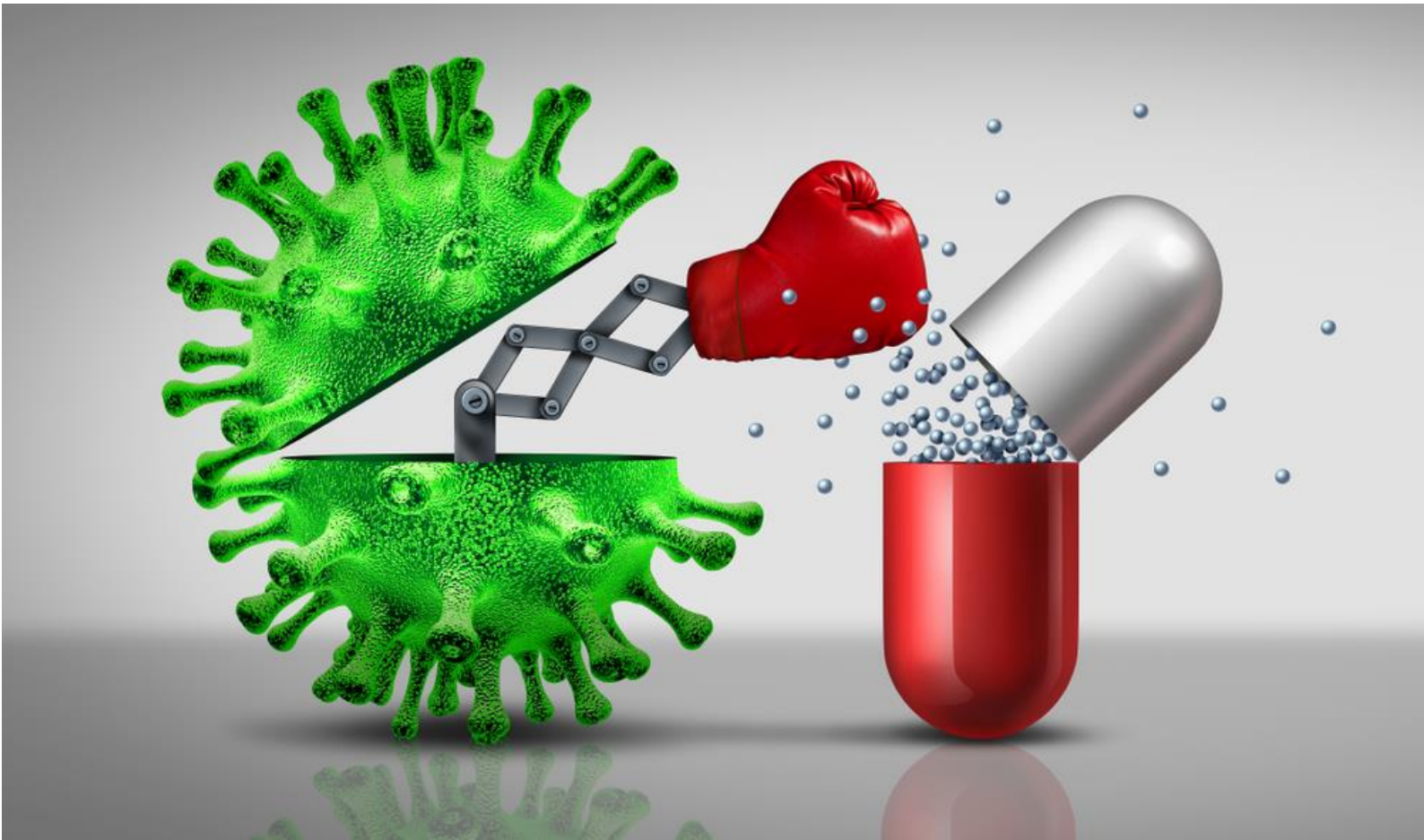
Bugworks' IP has multiple layers. Their main IP is the novel compounds that come out of their platform, which are patented in many countries. The platform technology which is a combination of expertise in infection biology, computational biology, computational chemistry, machine learning and pharmaceutical drug formulations is held as trade secrets.

This platform technology and the process Bugworks went through to put it together, is potentially capable of being applied to other areas also, not just bacterial infections. Bugworks' platform is one-of-a-kind globally.

In 2017, Bugworks was awarded the globally coveted CARB-X grant and was the only company from outside of the US and EU to win this award for Antibiotics innovation.

In addition, the company closed its series A round of funding in mid-2018, led by UTEC Japan with syndication from 3one4 Capital, Acquipharma Holdings South Africa and reputed angel investors from India.

Bugworks has been recognised by many media companies and scientific organisations including the BBC, Forbes, United Nations, World Health Organization and Government of India's Department of Biotechnology. Most recently Global research firm CB Insights has listed Bugworks as one of the 36 game-changing startups of 2019.



Coeo Labs: breathing life into newborns and critical-care patients

This startup is helping new-born babies combat respiratory problems and ensuring patients on a ventilator breathe easy with its indigenous medtech devices that save lives by preventing 'preventable deaths'.

While participating in a clinical-needs analysis programme run by the InnAccel AIM Fellowship in 2014 at St John's Hospital, Bengaluru, **Nitesh K. Jangir and Nachiket Deval** witnessed a completely avoidable tragedy. What made it worse was that it was a common enough occurrence.

A family was moving their new-born from another hospital in an autorickshaw. The baby was suffering from a common respiratory problem called respiratory distress syndrome (RDS) and was being transferred to the tertiary care hospital. But with no medical infrastructure to support the baby's breathing during the transfer, the parents lost the infant even before doctors at St John's could begin treatment.

Research on RDS showed that in India alone, more than 162,000 babies die every year. Of these, over 30 percent deaths occur due to the lack of infrastructure at hospitals without a neonatal ICU, or during transportation to specialist hospitals.

They also found that a stand-alone Continuous Positive Airway Pressure (CPAP) device, which is used to help babies with RDS, costs more than Rs. 150,000, making it unaffordable to stock such devices at primary and rural care centres.

While doing a deep-dive as part of their participation in the clinical-needs analysis programme, they also found that ventilator-associated pneumonia was a common global problem that needed to be addressed. In India alone, 6 lakh patients get Ventilator Associated Pneumonia (VAP) each year, with the mortality associated with this condition as high as 40 percent.

That year, Nachiket and Nitesh participated in a medical hackathon, where they met **Dr Data Santorino** from MUST Uganda who pitched the same problem during the event and recounted similar problems faced in Africa. The three, along with **Dr Kristian Olson**, a professor at Harvard Medical School and Director of CAMTech, and **Dr. Jagdish Chaturvedi**, came up with the idea to build Saans.

Since Coeo Labs was launched in October 2014, Nitesh, Nachiket and their team have built innovative medtech solutions to save precious human lives. Backed by InnAccel, Biotechnology Industry Research Assistance Council (BIRAC), C-CAMP, and Department of Biotechnology, among others, the two entrepreneurs have been on a quest to address unmet needs in the healthcare industry by engineering innovative, high-quality medtech devices for not just the Indian market but across the globe.

Saans is a novel, indigenous solution to help babies breathe easy

The foundation on which Saans was built is simple: **provide a breathing support system that does not have any dependency**, be it on physical infrastructure or the availability of a trained clinical person. They were clear that the

Coeo Labs founders Nachiket Deval and Nitesh K. Jangir with the VAPCare and Saans devices

device they build would be of gold standard quality, low cost, and be applicable for use across the globe.

Today, Saans, which in Hindi means ‘breath’, does what the name itself implies - give life to babies suffering from respiratory problems.

The founders say that the right materials made sure the company could bring down the cost and claim that the Saans CPAP costs one-third of multinational CPAPs in the market.

What’s more, the Coeo Labs team has designed Saans as the **world’s only neonatal mechanical CPAP device that can work with or without electricity, as it has an inbuilt battery backup.** The simple-to-use, portable device can also work when oxygen is available, or be operated manually by pumping air like with a regular air pump.

Most crucially, Saans can convert variable air pressure into a constant air flow that is needed for a baby with RDS. Plus, it’s designed to ensure it’s simple enough for the parents or relatives to use the device, without any formal training in situations where a healthcare worker is not available to give CPAP.

Saans, which is now ready for commercial use, has completed a clinical evaluation on 50 neonates and achieved success in delivering CPAP from this device.

VAPCare is the first-of-its-kind medtech device solving a global problem

Coeo Labs’ VAPCare device, which was a project funded by BIRAC, is also the first-of-its-kind intelligent secretion management and oral hygiene system that reduces the risk of ventilator associated infections for patients in critical care.

Until recently, infections in patients on ventilator, called aspiration pneumonia, was considered a ‘drug problem’, which could be treated by giving antibiotics. The duo realised that there is a hard-core engineering problem where saliva and secretions accumulate and go inside the lungs. Taking an engineering approach, they wanted to build a device that

made sure that none of these secretions roll down and remove it from multiple locations.

Research shows that aspiration of infectious bacteria present in the oropharynx, the area behind the mouth that is in the middle part of the throat, and the gastrointestinal or digestive tract is the main cause of ventilator associated pneumonia, a common cause of death in ICU patients who are on long-term ventilator care.

VAPCare, the only device that can remove secretions from multiple locations, uses artificial intelligence and sensor-based technology to manage secretions and oral hygiene in the oral cavity, the oropharyngeal, and the subglottic areas.

In doing so, it ensures these secretions do not reach the lungs and cause infections. VAPCare's unique sensor-based technology detects the presence of secretions and ensures no suctioning is done in the absence of secretions so as to avoid any injuries.

This makes VAPCare the only device that can auto-detect secretions and automatically push in mouthwash and remove the fluid regularly, thus doing away with dependencies on healthcare workers. It is also compatible with all ventilator machines and is non-invasive.

VAPCare, which has been used in nine hospitals across multiple states in India, has been effective. The device, which is in commercial stage, has been granted patents in the US, China, and India, receiving widespread appreciation and interest from doctors in different markets.

Growth and future plans

The duo is all set to run pilot programmes for Saans in multiple states across India, wherein each state that uses this device will generate data on its impact, which will ultimately be made available to the government for deployment across all healthcare centres. The aim is to deploy Saans at both public and private healthcare centres, as many small nursing homes in Tier I cities also do not provide this kind of CPAP facility.

To put it simply, Coeo Labs has made it its mission to breathe life into every new-born through Saans, as also through its other medtech inventions such as VAPCare, which prevents the risk of ventilator associated pneumonia.

As Nachiket poignantly says, "The next big thing for Coeo Labs would be to scale up. Taking our devices to all possible patients, all the people for whom this would have an impact. In short, to take it to the masses and to ensure that there is impact because of what we are doing."

Saans is now ready for commercial use, having completed a clinical evaluation on 50 neonates and achieved success in delivering.

VAPCare is the only device that can auto-detect secretions and automatically push in mouthwash and remove the fluid regularly, thus doing away with dependencies on healthcare workers. It is also compatible with all ventilator machines and is non-invasive.

Pandorum Technologies: looking to 3D-print human organs on demand

This Bengaluru-based biotech startup has created functional tissues of the cornea and the liver, which can eventually be 3D-printed as human organs, on-demand.

The scientific and medical community comes up with breakthroughs that save lives, fighting illnesses and discovering new and better ways to live. And these breakthroughs are not just happening in heavily funded research centres; they are happening at startups headed by enthusiastic scientists as well.

Pandorum Technologies Pvt. Ltd. is one such company that is working on some cutting-edge science in healthcare. **Founded in 2011 by IISc alumni Dr Arun Chandru and Dr Tuhin Bhowmick,** this Bengaluru-based biotech company focuses on tissue engineering and regenerative medicine. The tissues can be grown in *in-vitro* (in a laboratory) conditions with a pseudo *in-vivo* (internal body condition) environment.

The company designs and manufactures 3D functional tissues that can be useful for therapeutics and medical research. Liver cells usually cannot grow outside the body. However, with the technology used by Pandorum and with suitable biomaterials, they can be grown in labs and used for medical trials, thus reducing the dependence on animal and human trials.

Usually, scientists use 2D cell cultures and animals for their lab testing, which does not produce accurate results. Arun was quoted in a media report as saying that the tissue they had developed has 10 million cells and can be used in medical research – primarily disease modelling and studying the radiation effects.

Using 3D bioprinting technology, Pandorum Technologies focuses on the goal of bringing about a long-term change in the medical sciences and the research techniques and ultimately have tissues ready for real transplantation of organs. They aim to design “homo-chippiens” (a miniature body part on a chip) for medical research and human organs for therapeutics.

The firm concentrates on two ‘Growth Pillars’, namely 3D Human Liver Organoids and Bioengineered Human Cornea.

How it works: 3D human liver organoids

Drug development requires a lot of research and lab testing and most of these tests are done on animals, which is highly unethical and does not produce accurate results. The artificial tissue engineered by Pandorum effectively reduces the cost, time and risk associated with drug development and research.

These organoids have long-term survivability, native tissue-like microarchitecture (the structure is similar to the original organ), elevated gene expression (which means that the genetics allow the desired product to be easily formed) and can be customised for desired tests.

Pandorum’s ability to grow 3D structures shows remarkable stability in 3D printing process innovation. Further, cells grown in a 3D

Pandorum works with the L. V. Prasad Eye Institute to target this problem with regenerative treatment using a bio-engineered 'liquid cornea' developed on a scaffold and then applied and sutured in a diseased or damaged human eye.

structure improve the long-term survivability compared to a 2D system.

This, in turn, means that the synthetic liver tissue is close enough to human tissue to be able to emphatically develop and test drugs on it. The synthetic tissue can perform functions of a human liver tissue including detoxification, metabolism, and secretion of biochemicals such as albumin and cholesterol. This paves the way for eliminating the need for human test cases and clinical trials, or other animals.

To build liver tissue of 5mm thickness, Pandorum needed 10 million liver cells that were arranged in three-dimensional architecture, a bio-material made up of glucose, proteins and living cells extracted from a particular type of insect used as ink, which is placed in three interchangeable dispensers of the printer's head controlled by lasers.

How it works: Bioengineered human cornea

Corneal blindness is a growing issue in India – about 1.2 million Indians suffer from Bilateral Corneal Blindness and about five million to six million people have unilateral involvement. Every year, there are about 25,000 to 30,000 such cases, including those of children below the age of six.

Transplants are limited primarily because of the lack of donors and due to a shortage of cornea specialists. With only about 400 to 500 specialists in the country who can do keratoplasty - operation on the cornea - there is a serious imbalance in numbers.

Further, more than half of all donated corneas do not meet organ transplant requirements. So, an alternative like in-vivo regeneration therapies are the need of the hour.

Pandorum works with the L. V. Prasad Eye Institute to target this problem with regenerative treatment using a bio-engineered 'liquid cornea' developed on a scaffold and then applied and sutured in a diseased or damaged human eye.

Future impact potential

The overall impact can be seen in the future with the improved quality of drugs, reduced animal testing, implantable tissues and organoids and a set of grafts of the skin, cornea, etc. The company has a vision of being able to manufacture organs on demand, a factor that eliminates the pressure of finding a donor that matches the patient. This includes implantable tissues, skin, blood vessels, personalised and on-demand organs, and tissue-based life support systems**.**

In 2018, Pandorum raised a Series A funding of $3.6 million from the **Indian Angel Network Fund, 021 Capital, 500 Startups** and the Karnataka government-backed **Karnataka Information Technology Venture Capital (KITVEN) fund.** Flipkart Co-founder **Binny Bansal** also participated. The investment is meant to help in advancing their product from the prototype to the market-ready stage.

Strand Life Sciences: making accurate treatment possible via genomic testing

Be it cancer, genetic diseases, or even PCOS, Strand Life Sciences has a range of tests that provide patients with accurate information to decide on the next steps in their treatment.

Strand Life Sciences is a global bioinformatics and genomic profiling company that builds technology for life sciences research and also conducts tests in oncology, genomics and precision medicine. **It was established in 2000 by four professors from the Indian Institute of Science - Vijay Chandru, Ramesh Hariharan, Swami Manohar, V. Vinay -** as one of the first academic entrepreneurship ventures in India with the goal of combining computer sciences and life sciences to further research and medical applications.

Strand's stack of artificial intelligence (AI)-powered bioinformatics and text mining platforms is built on the award-winning platform 'Avadis' and is used by researchers across the globe from academic institutes, clinical labs, and pharmaceutical companies to analyse data from high-throughput life sciences experiments. This technology is also used to provide a complete range of diagnostics in the fields of oncology, genetics, women's health, infectious diseases, and wellness. Strand's services include:

- Clinical diagnostics for the Indian market
- Bioinformatics tools and services for the global market
- Clinical research services for the global market

What sets Strand apart is its deep expertise, two decades of experience, and the substantial impact it has already made. Strand's technology platforms have been used by researchers across the globe to advance the state of knowledge leading more than 20,000 citations in peer-reviewed literature. Strand is a pioneer of genomics-based diagnostics in India and has helped more than 10,000 patients achieve a diagnosis when none was available earlier. **Strand built the first College of American Pathologists (CAP)-accredited laboratory for genomics in South Asia.** Strand's publications on the genomic landscape of cancer mutations in India are among the first large scale studies on the topic in India. Strand's 800-strong workforce is drawn from the best computer science and life sciences institutes in India and the world, including the IITs, IISc, MIT, NYU, NIH, etc, with more than 30 PhDs and 10 MDs.

How Strand's precision medicine works

Oncology: Today, cancer therapy decisions are made based on the 'molecular profile' of the tumour cells, the fingerprint of cancer cells. Strand has a range of tests based on the latest technology that can support cancer detection, diagnosis and therapy in many ways. Hereditary Risk Prediction tests help identify those at a higher than normal risk for cancer on account of genomic mutations. Liquid Biopsy tests help track cancer progression non-invasively and could also enable early detection in the future. Tumour

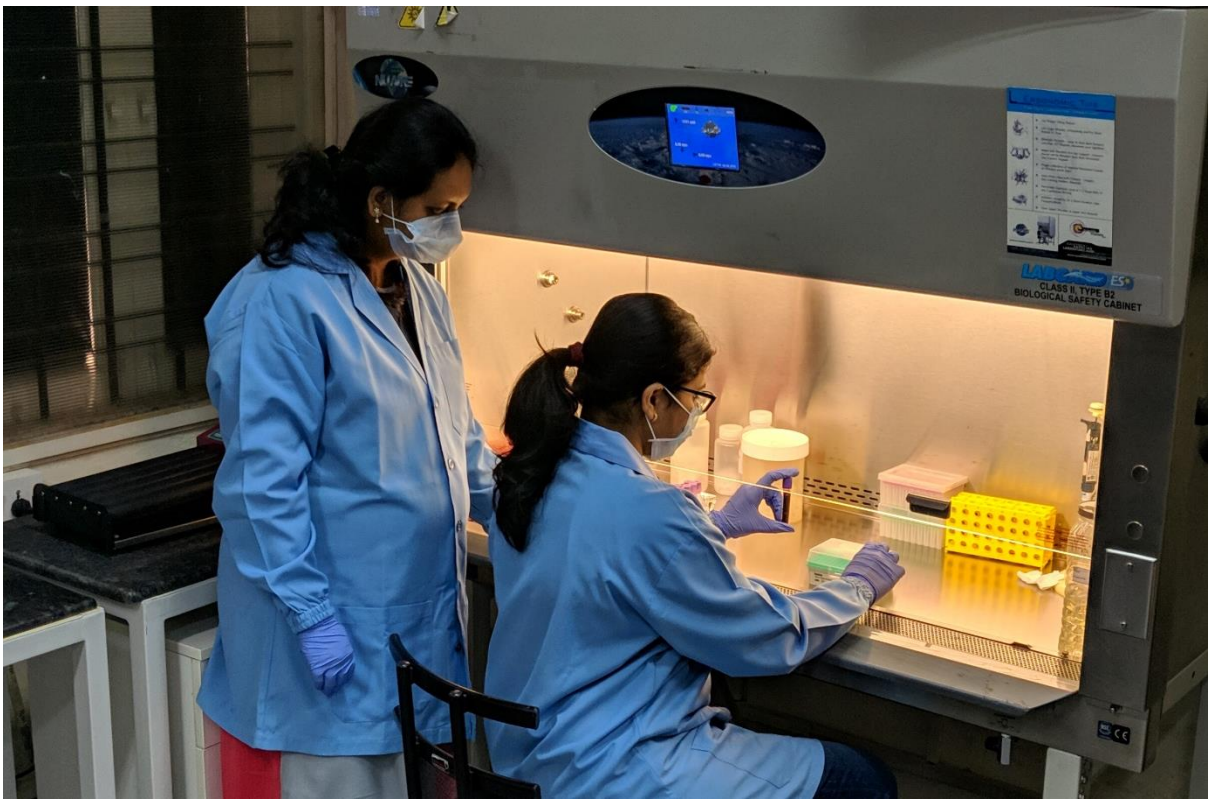
Profiling tests help identify the right targeted therapeutic strategy. Strand has the most comprehensive portfolio of oncology tests in the country.

Genetics: Many diseases arise on account of hereditary genomic mutations, and that is where a genetic test can change the game. Strand's Clinical Exome test provides underlying genetic information for more than 6,000 inherited disease conditions by analysing ~4,000 genes associated with known clinical phenotypes for the presence of mutations. Strand's genomic diagnostic rates are among the best in the world on account of its deep analytical technology that allows Strand to call even the more complex mutations.

Women's health: Women's health testing revolves around pregnancy (prenatal testing for foetal defects including Down's syndrome), menstrual health (gonadal function tests, including PCOS), aging (mineral and bone metabolism tests) and cancer screening (for inherited cancer-causing mutations and for other cancers like cervical cancer). Strand offers a comprehensive collection of such tests.

Infectious diseases: Strand's comprehensive tests also help detect communicable diseases caused by bacteria, virus and other pathogenic cultures. The tests help detect the presence of pathogens and pathogenic proteins in the blood, and antibodies produced in response to an infection.

Wellness: Strand provides a range of 550+ diagnostic tests that help regulate and maintain wellness and can be integrated into a health management programme. Strand's wellness tests use test measurements in conjunction with data-driven risk prediction methods to provide a 10-year risk of serious cardiac, kidney and liver disease.



Strand has the most comprehensive portfolio of oncology tests in the country

Inside a Strand Life Sciences facility

Fertility: Strand's Non-Invasive Prenatal Test (NIPT) helps identify if an expectant mother is bearing a child with one of these genetic disorders – Down Syndrome, Patau Syndrome and Edwards Syndrome. Other tests that test fertility like Luteinising Hormone tests, Follicular Stimulating Hormone tests, and many others are available as well. Pre-implantation Genetic Screening/Diagnosis (PGS/PGD) to be released shortly.

Growth and future plans

On the diagnostics side, Strand has been building depth and breadth over the last year. In February 2018, Strand raised $13 million from Quadria Capital and its affiliates. Around the same time, it acquired Triesta Sciences, the clinical diagnostics laboratory of HealthCare Global Enterprises Ltd (HCG), thus creating a comprehensive oncology practice as well as a footprint of laboratories across the country. In December 2018, Strand acquired the Indian medical diagnostics business of the New Jersey-based **Quest Diagnostics**, a global provider of diagnostic information, thus creating strong women's health and wellness practices, as also a strong footprint in North India. This now provides Strand with a strong platform with geographical presence across the country, strong hospital relationships, a comprehensive offering ranging from cutting-edge genomic tests to more routine biochemistry tests, and strong technology and R&D backbone to scale in India and in other geographies.

On the technology and research side, Strand has been actively growing its clientele in the west with its unique proposition of combining best of breed bioinformatics, laboratory assays and clinical operations to answer questions in various therapeutic areas, across oncology, respiratory disease, gastrointestinal disease, dermatological disease, and liver disease.

Teleradiology Solutions: making AI-enabled diagnosis accessible to patients anytime, anywhere

Teleradiology Solutions is countering the global shortage of radiologists by having an AI-driven solution complete the first round of diagnosis. This lets radiologists review more scans and gives clients faster, more accurate diagnoses.

A major issue in the healthcare industry is the lack of radiologists to complete a review of scans to allow for a medical problem to be diagnosed. It is a problem that is especially acute in rural areas where there is a shortage of equipment as well as qualified personnel. Two Yale alumni - **Sunita Maheshwari and Arjun Kalyanpur** – zeroed in on coming up with a solution that can disrupt access to timely treatment for large, underserved parts of India's population.

These US-trained doctors returned to India in the early 2000s to try and make a difference by providing high-quality healthcare. Arjun ended up working for Yale out of Bengaluru, reviewing radiology scans. This turned into a business idea – an outsourced setup to allow US hospitals get scans reviewed overnight.

Soon, this grew into a global setup. Today, it helps doctors work with patients from across the world by simply digitising data obtained from their radiology scans and sending them across to respective doctors without any hassle.

How and why it works

Globally, there is a shortage of radiologists around the world, more so in India. All these years, the group worked on making radiologists more efficient to be able to report more diagnostic studies per day, helping patients around the world with high quality reports.

The platform, RadSpa, that was built by their tech team enabled a teleradiology workflow to be implemented. It takes the radiology scans sent from anywhere in the world, assigns it to the appropriate radiologist who process the images and sends back the results, along with a preliminary diagnosis.

Teleradiology Solutions provides many different services and quality reporting for scans for trauma, musculoskeletal, neuroradiology, body and abdominal, vascular, and paediatric imaging.

Unlike many other young companies, the couple deliberately decided not to raise external funding, which allowed the business to grow at its own pace and in the way they wanted it to.

The intersection of science and technology

At Teleradiology Solutions, doctors and technologists work together to understand each other's perspective to create new products at the intersection of health and technology, with the goal of more accurate reports and more efficient radiologists.

Sunita Maheshwari and Arjun Kalyanpur, Founders of Teleradiology Solutions

As artificial algorithms began to enter the health care space, the group has worked on building their own AI diagnostic algorithms as well as partnering with AI companies to deploy their AI tools onto RadSpa for the radiologists to use.

Telerad tech's first AI algorithm is Mammo-assist which can auto-detect breast cancer. The benefits of an AI enabled intelligent workflow platform are two-fold. For one, the efficiency tools help each radiologist process a much greater number of scans than they would if the process was manual. Next, it also allows for more accurate diagnosis cutting down on medical errors.

The impact of the solution

Apart from entrepreneurship, the founders had a larger aim - to provide quality healthcare to the people of India, especially in rural areas. They are now doing this by bringing services to rural India via setting up teleradiology for governments such as they have done for the state of Tripura as part of the National Health Mission. Through the **Telerad Foundation**, they provide high quality diagnostics to poor patients at charitable hospitals, such as the Ramakrishna mission hospitals. In addition, they are helping test technologies in partnership with the Gates Foundation for the automated detection of tuberculosis, which can be game changing for the public health of India.

Working in the area of public health brings with it the advantage of gaining deep insights based on the large volumes of radiology data available. This in turn will help establish community and national-level patterns in data and genomics, longitudinal analysis and creation of virtual GPs to cater to population. Zhong An Health of China has already achieved this at some scale

India doesn't need to be far behind.

Also, under way is a pursuit of radio-omics or the intersection of radiology with genomics to personalise solutions.

Growth and future plans

Apart from Teleradiology Solutions and Telerad Tech, the group has a chain of primary care clinics in Bangalore called RXDX where

telemedicine solutions are deployed. The group currently has a staff strength of about 600 including 150 doctors and over 75 radiologists along with other professionals like data entry operators, transcriptionists, administrative, IT, finance and HR professionals. The group clocked Rs 100 crore in income in 2016-2017 and will end 2018 at a top line of 135 crore. It aims to touch at least Rs 170 crore in the next financial year. Here's a quick look at its other solutions.

Tele 3D Imaging: Through a tie up with Harvard's Mass General hospital, the company runs a 3D lab in India. While it is important to do a complete scan of the affected area, Tele 3D Imaging provides a way to handle complex vascular and neuroimaging cases. For complications like aortic or cerebral aneurysms, the 3D imaging technique provides a thorough scan of the entire complexity that enhances the accuracy of the report. This also facilitates the understanding of the problem and allows for better planning of the treatment.

Quality Over-Read: Quality Over-Read is a peer review of the reports of a radiologist or radiologist group while simultaneously reviewing the examinations to assess the quality and ensure compliance with the standard of patient care. This allows radiologists to get quality information about a patient's disorders and improve the standard of analysis. The group provides Over-Read/Second Opinion Services wherein their radiologist group performs retrospective reviews on reports according to a client's request and grade them based on the American College of Radiology Peer Review Scoring System.

Clinical Trials: Via Image Core Labs, Teleradiology solutions provides clinical trial imaging solutions with an integrated image management capability. This makes it easy to access quality and cost-effective reports in any phase of a clinical trial or to have algorithms tested. Their image core lab has tie ups with several entities including Biocon, Alkem. Stempeutics, Polypid. Zebra and more.

Tonbo Imaging: working to make the world a safer, more secure place for us all

Bengaluru-based Tonbo Imaging designs and deploys advanced imaging and sensor systems for military reconnaissance, infrastructure security and transportation safety.

The eye of a dragonfly is a complex structure; it comprises tinier ommatidia, or eyes, and each of them processes an image. The image processed by each eye is then integrated into one. In other terms, one large aperture that lets in a certain amount of light is dominated by many tiny apertures letting in smaller amounts of light. That is the idea behind Tonbo's breakthrough imaging technology.

Founded by **Arvind Lakshmikumar, Ankit Kumar, Cecilia D'Souza and Sudeep George** in 2012, Tonbo Imaging designs, builds and deploys advanced imaging and sensor systems to sense, comprehend and control complex environments.

Tonbo Imaging builds unique imaging technology that uses multiple complementary sensors to allow users to see and interpret the environment around them. Tonbo uses this technology to make multi-sensor imaging products/systems for military, security, transportation safety and industrial inspection applications.

The world is growing towards a connected network of smart systems that are capable of "seeing" the environment around them and interpreting it in real-time to take control. From surveillance missions on the battlefield to smart cities, autonomous vehicles and automated inspection systems, the ability to see better and farther with the right contextual perspective for complete situational awareness is invaluable. Be it a soldier on the battlefield, an unmanned drone doing a reconnaissance mission in bad weather, a security guard looking through darkness and mist or a driver navigating fog, the ability to see their environment better supports better decision making. Real-time visual imaging and processing are integral to the success of all smart systems.

Tonbo's imaging systems offer real-time imaging simultaneously in day and night conditions, across both visible and infrared spectrums. With sophisticated onboard vision processing, Tonbo's imagers enable a complete understanding of the environment in all weather and low visibility conditions like fog, high winds, dust, rain, smoke, camouflage, etc.

Tonbo's technology is a combination of fundamental innovations in the image acquisition process along with powerful computer vision algorithms to support superior imaging and scene interpretation for a large

> Tonbo is the only company based in a non-NATO country to make technology and product sales to the US Military, Special Forces and DARPA. They are the only Indian company to be an OEM and exporter of imaging and strategic electronics systems.

RAPTOR from Tonbo Imaging is a small, lightweight multi-purpose uncooled thermal imaging sight designed and optimised for small and medium caliber weapons and can be used as a standalone sight, handheld scope or even as a helmet-mounted sight.

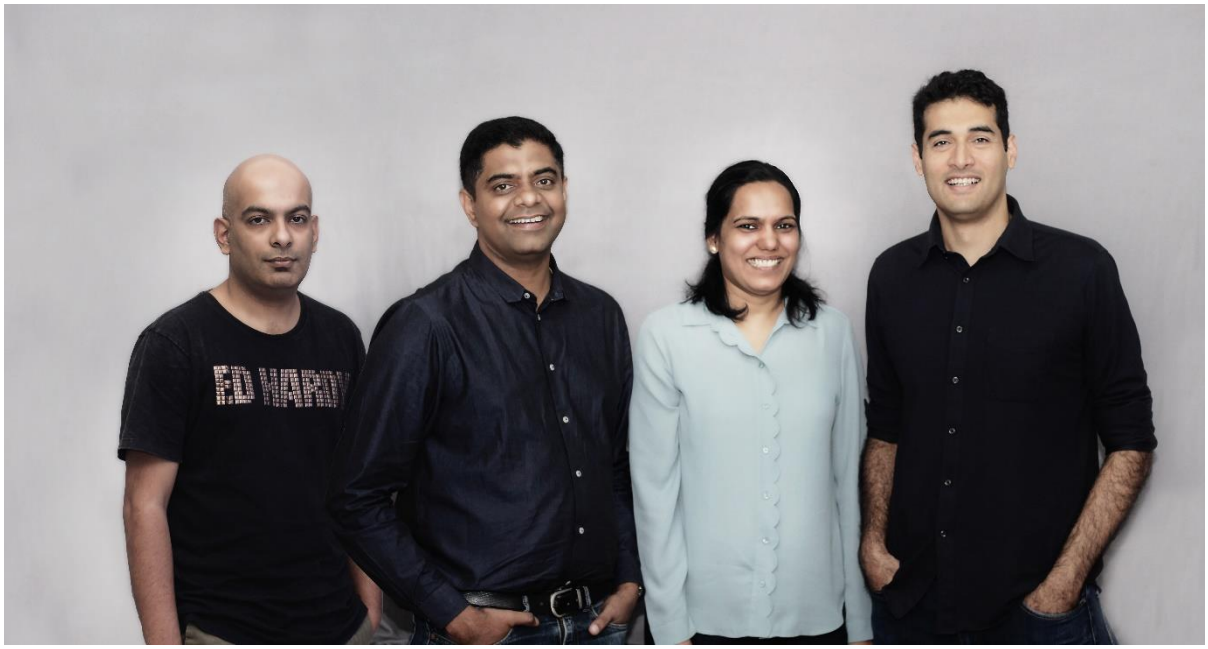
range of applications. Tonbo leverages the computing power and scale of consumer electronics hardware to build systems that outperform existing technology in size, weight, power and cost.

Tonbo's biggest achievement is creating a disruption in the procurement of military electro-optics systems and democratizing night vision technology. Previously only available in developed countries, emerging markets (India, South Asia, South America) have always needed high-end electro-optics and imaging systems for surveillance, reconnaissance and targeting. Electro-optics forms the backbone for any modern-day military system across guns, tanks, ships and UAVs. The current default products that were made available to the forces in these countries was night vision based on image intensifier technology or large and expensive thermal imaging systems. Thermal imaging was perceived to be complex, expensive and was restricted.

With Tonbo's technology, night vision became cheaper, easier to integrate and completely unrestricted. Tonbo is the only company based in a non-NATO country to make technology and product sales to the United States Military, Special Forces and DARPA. They are the only Indian company to be an OEM and exporter of imaging and strategic electronics systems. From a start in 2012, they have become a part of electro-optics military programs in 25 countries, winning multi-year program contracts.

What it does and how that works

For over 200 years, visual imaging systems have been designed the same way - a highly inefficient process isolating the image capture and image analysis process. Improvements have been done over these years through better optics, sensors and image processing. However, through this evolution, the underlying imaging model has remained essentially the same. With all these improvements, we have good imaging systems, but not smart imaging systems that



The Tonbo Imaging core team

are needed for the multiple intelligent platforms that are going to be prevalent in the future.

The basis of Tonbo's technology is to create context-aware, smart imaging systems. Tonbo's technology focuses on how efficient imaging systems can be created by balancing image capture (Optics), Image Processing (Camera Pipeline) and Computer Vision (Scene Interpretation) into one single system.

- Micro-optics and Microscanning for better imaging
- Multi-sensor fusion for continuous day/night imaging
- Inertial sensing to correlate motion and image capture
- Efficient imaging and computer vision software that can manage the complexity of computational imaging

Tonbo has produced numerous products in various categories. Their product portfolio spans across tactical systems that are carried by soldiers/mounted on their weapons to large surveillance platforms that form the intelligence and reconnaissance payloads on UAVs, missiles and tanks.

Tonbo's tactical imaging systems are designed for combat missions addressing the needs of the military and special forces. Supporting day and night surveillance, these systems address the spectrum of observation, precision engagement and communication.

The company's tactical portfolio provides future infantry soldiers with an array of multi-sensor systems that span across visible and infrared wavelengths providing the soldier with a wide array of tools for day and night engagement.

Tonbo's tactical sights portfolio is one of the largest in the world and has been deployed across numerous operations. From fighting terrorists in the Uri attack in Jammu & Kashmir to defending Pathankot after the insurgency, these thermal weapon sights have found large scale field deployment. Internationally, Tonbo's tactical sights have been deployed across South Asia, South America, United Kingdom, South

T-Rex is an advanced long-range reconnaissance and observation system. It includes a very long-range day optical imager and a cooled area scan thermal imager integrated with a 20km eye safe laser range finder, GPS and magnetic compass all in one compact and modular system

America and the United States. Recently, the company won a $100M, multi-year program to modernise the Peruvian Armed Forces.

As land vehicles manoeuvre through difficult terrain, it is imperative that the drivers are able to support their mission and ensure crew safety. Tonbo's "Enhanced Vehicle Imaging Platform" provides comprehensive 360-degree situational awareness for drivers and the crew in the day, night and all-weather conditions.

For air and naval systems, Tonbo provides a number of optronics systems consisting of multi-sensor imaging modules catering to the needs of surveillance, monitoring, panoramic search and track and fire control. These electro-optics systems are offered in a wide range of options suiting various mission profiles.

Tonbo's reconnaissance, surveillance and targeting platforms are part of numerous global programs and are being integrated across various classes of UAV's, armoured fighting vehicles and missile platforms.

Growth and future plans

Tonbo has raised over Rs. 200 crores in funding from a marquee list of venture investors – **Artiman Ventures, Qualcomm Ventures, Walden Riverwood Ventures and Edelweiss.** In the last six years, the company has expanded to over 200 people and is present in Singapore, India, the US and Lithuania. With over Rs.150 crore in revenue, the company is now a part of global programs and has a sales pipeline of over Rs. 1000 crores.

Tonbo's technology is not limited to the defence market. They have used defence as a beachhead for their technology. Their products are military qualified and commercially built. Which means that they have the rigour of a military system and the economics and scale of a commercial system.

Tonbo's technology has found applications beyond defence and security. The company is now expanding into imaging technology for recreational observation, transportation safety systems for heavy vehicles and infrastructure security for smart cities.

ToneTag: powering commerce with sound and without depending on the internet

ToneTag uses sound waves to enable payments on devices to merchants, no matter what hardware or infrastructure you use.

In India, how many times did you have to pay slightly extra because the merchant did not have change? Almost all Indians have had to face the problem of tendering the exact change or else we get a bunch of candies in place of lower denominations. Every Indian would have also faced a situation where they did not buy a product because the retailer does not want to part with change.

To overcome this, **Kumar Abhishek and Vivek Singh founded ToneTag,** which sports the tagline, a shopper's best friend. ToneTag's technology converts data into sound waves and avoids the complications of wires and "tap-and-go" connections. In fact, the technology understands the biggest problem that most Indians do not even own a smartphone.

How do the payments work?

Imagine you're buying something, and you don't have cash, but you do have a mobile wallet on your smart phone. That's good for you but might not be good enough because the retailer cannot afford a smartphone or a card machine. Or what if you both use the same mobile wallet, but neither of you can connect to the internet.

That is where ToneTag comes in. The company uses a technology that emits encrypted sound waves from a pod to your smartphone. These sound waves are a result of the company's proprietary software development kit (SDK), which converts data into sound waves.

It can function without electricity for hours and doesn't need an internet connection, which sets it apart from regular EDS and point-of-sale (PoS) devices.

Customers with a smartphone or feature phone connect to the device through soundwaves. Once a phone is brought close to the pod, the customer is promoted to enter a PIN (if using the interactive voice response facility). Then the amount is entered, and the payment completed.

Further, ToneTag has also worked with merchants to enable over 1.5 lakh regular PoS machines to accept this mode of contactless payment with a simple software upgrade.

ToneTag makes digital payment options available to all Indian merchants at a minimum licence fee that helps them with easy and quick transactions without a hassle and long, tiring queues. This enables quick payments at toll plazas, faster checkouts at parking lots, petrol pumps, supermarkets, in-flight payments, and book tickets at the railway station.

As Founder Kumar Abhishek says, "Experience is the core of any technology. Keeping the customer's accessibility and convenience in mind, technologies must work backwards to deliver a solution that will enable anybody to make digital transactions."

According to Abhishek, ToneTag has reached 50 million consumers and is gunning to double

that number before the end of the financial year.

Where it can make a difference

ToneTag plays a major role in retail development, as well. At present, it allows businesses to circulate information when customers are nearby like useful offers and deals. But going forward, ToneTag's technology can enable an Amazon-Go kind of experience, where shoppers can pick up what they need and walk out. The payments will be handled by sound waves through their phones. The same applies to payments made for online orders at the point of delivery – "cashless-on-delivery" via digital payments on any phone.

ToneTag has raised $10.3 million in funding from investors that include **Amazon, Mastercard, Reliance Capital, and 3one4 Capital.** ToneTag's technology facilitates convenience when it comes to payments in different forms. Here's a quick look at the technology and use cases.

ToneTag's product line

The RetailPod: A small, circular device that can be used by retailers to allow their customers to make cashless payments by placing their phones over these devices. The RetailPod emits a sound that is detected by the phone and the payment happens almost instantly and the retailer receives an audio or visual acknowledgement in real-time.

Contactless ATMs: Much like EDC machines, a software upgrade enables ToneTag's technology in existing ATM machines and allow cardless transactions.

Payment kiosks: Customers can easily pay at kiosks without having the fear of another person snooping in on their private details as the technology masks confidential information by playing a secure tone from the customer's phone.

Sonic Cast: ToneTag's 'Sonic Cast' allows a consumer to transmit information through a TV, radio and other digital displays. This simplifies activities like teleshopping purchases without the hassle of making numerous phone calls with one click on the phone.

Pick & Go: This technology allows customers to pick up products from a store and have their money deducted on the go without even stopping at the counter, eliminating the need for queues.

Kumar Abhishek and Vivek Kumar Singh, founders of ToneTag

India finally takes the quantum leap in computing

In 2018, the Department of Science and Technology, Government of India, launched a new programme – Interdisciplinary Cyber-Physical Systems (ICPS) – to nurture and promote research and development in this field. A major initiative by the ICPS is QuEST, a Rs 80-crore programme meant to roll out the infrastructure for quantum computing.

Worldwide, quantum computing is believed to be the technology that can crunch the time needed to solve some of the most complex problems affecting the human race and the world we inhabit. As of now, only prototypes of quantum computers exist.

With Moore's Law ("the number of transistors in a densely integrated circuit doubles about every two years") destined to reach its limits eventually, quantum computing could potentially take over. To explain it plainly, a single quantum computer could theoretically surpass all the current supercomputers of the world combined. This would be a boon in several areas including cryptography, online banking, national security, database management, financial analysis and weather prediction. As a result, no government can afford to be left behind in this race.

In 2017, the Indian **Department of Science and Technology (DST)** decided to plunge into quantum computers through the Quantum-Enabled Science and Technology (QuEST) mission. The aim is to develop and demonstrate quantum computers, communication and cryptography. The department also plans to develop advanced mathematical quantum techniques, algorithms and theory of quantum information systems.

According to a DST statement, QuEST "promises to revolutionise future computation and communication systems, which will ultimately have a huge impact on the nation and our society as a whole".

The first step is to create the infrastructure. In 2019, India will finally go full steam ahead, starting by rolling out the required infrastructure with an initial budget of Rs 80 crore. With very few people are working on it, quantum computing is a relatively new field for the country, so this is quite an ambitious and audacious move. At present, India lags a lot of countries in this field and this may just be our chance to catch up and maybe even overtake a few of them.

In the next three years, India would step into the next phase, which is worth Rs 300 crore with the **Defence Research and Development Organisation (DRDO), the Indian Space Research Organisation (ISRO) and the Department of Atomic Energy (DAE)** working together. As the project scales up, the budget could be increased significantly.

The Cyber-Physical System (CPS) network will see small centres and research parks being established in premier institutions like the Indian Institute of Science Bengaluru and IITs like the one in Kanpur from the year 2020.

In the next seven years, India plans to set up 20 CPS on the lines of IITs that will also focus on artificial intelligence (AI), big data and robotics,

apart from quantum communications, with the total outlay the range of a whopping Rs 3,600 crore.

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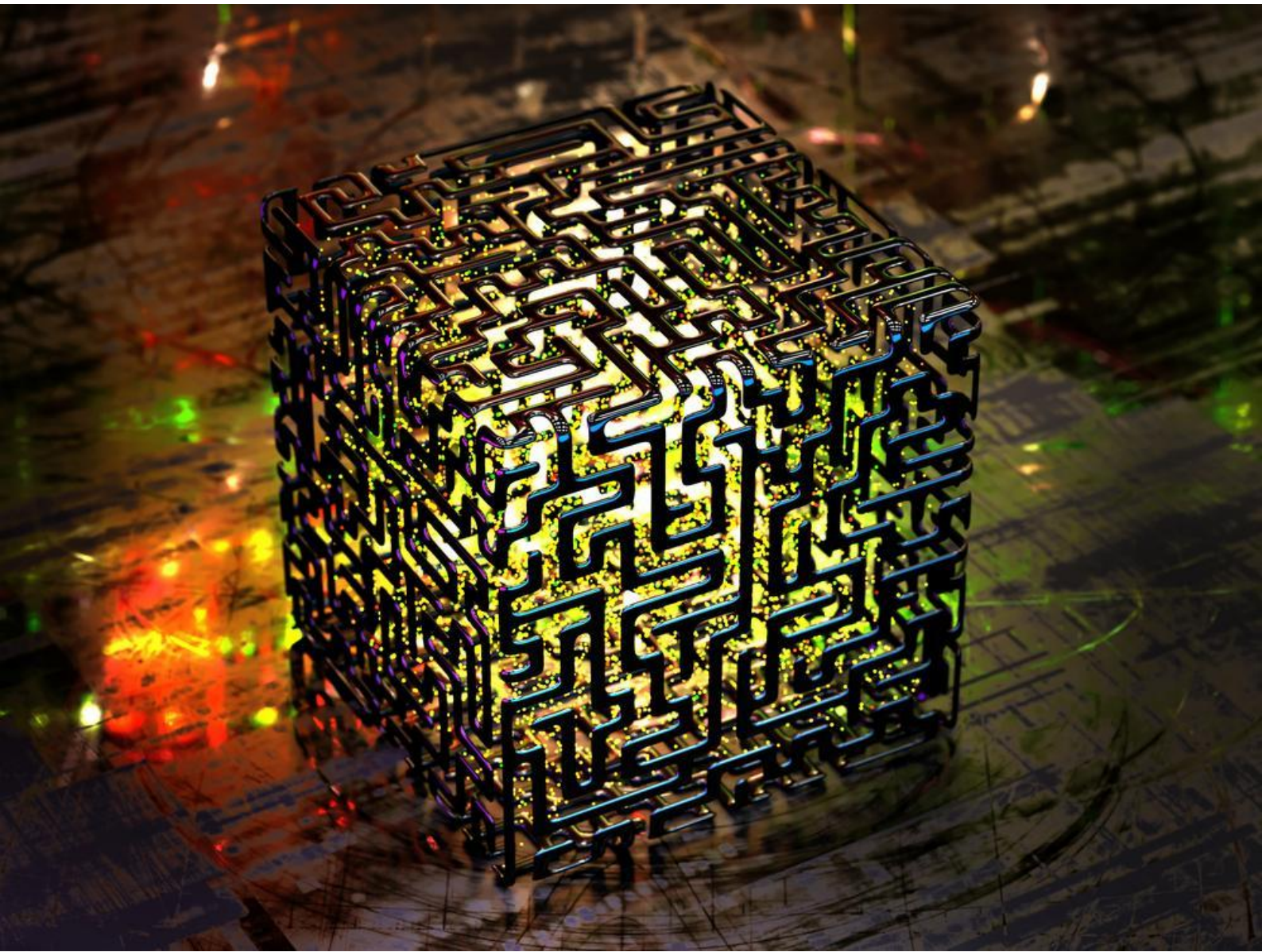
During his inaugural address at the 106th session of the Indian Science Congress, **Prime Minister Narendra Modi** stated that this money would be used for R&D, technology development, international collaborations, among other things.

In fact, India and Russia have already signed an agreement to increase cooperation in artificial intelligence and blockchain technologies. India has also set up an AI Task Force and Industrial Revolution 4.0 has been mentioned by the Prime Minister a few times.

At the event, **DST Secretary Professor Ashutosh Sharma** had said, “There will be a rise of the intelligent machines. There will be cyber-physical systems that will have the ability of perception, decision making and action. There will also be greater linkages, for example, a



> In the next three years, India would step into the next phase, which is worth Rs 300 crore with the DRDO, ISRO, and the Department of Atomic Energy working together. As the project scales up, the budget could be increased significantly.

network of driverless cars will learn from the mistakes of one another."

It is heartening to note that India is finally waking up to the future that will be ruled by the likes of AI, big data, robotics and quantum computers. The US is way ahead in these fields and China is fast catching up, but we believe that India has the manpower, intellectual capital and brains to beat them both.

The last few years saw India building offline infrastructure at a lightning pace, but online infrastructure will have to be built at an even greater speed and the CPS is a first powerful step in that direction.

About the Department of Science and Technology

The Department of Science & Technology (DST) was established in 1971, with the objective of promoting new areas of science and technology and function as the nodal department to organise and orchestrate related activities to promote related subjects.

It was entrusted with promoting high-end basic research and development of cutting-edge technologies to service the requirements of India's citizens by developing the right skills and technologies.

The Department also develops policies related to science and technology and supports capacity building, both in terms of infrastructure and human resources. It also enables the development and deployment of technologies and creates opportunities for societal interventions through science and technology. And finally, it sets up and runs mechanisms for co-operation, partnership sand alliances. According to the Department, it "enables cross cutting impacts across sectors to sustain growth/ development and synergies to optimize on time, human, institutional and financial resources".

The DST was the pioneer government agency to promote technology-driven entrepreneurship and incubation activity across the country for decades now. The initial focus was on capacity building, but for the past few years, this has expanded to include building institutional programmes like entrepreneur parks and business incubators. For the past decade or so, DST has focused on business and technical incubation.

After the launch of the **Startup India programme** in January 2016, the department widened its scope. It first announced an initiative to nurture innovative ideas in knowledge-based and technology driven startups via the National Initiative for Developing and Harnessing Innovations (NIDHI).

NIDHI is the umbrella programme that includes elements like PRAYAS (supporting ideas to prototype stage), Entrepreneurship-in-Residence (EiR) programmes, centres of excellence, seed support, etc. The goal is to create a pipeline of innovative startups from the ground up.

It also promotes entrepreneurship via its recognition and support of technology business incubators (TBIs) and Science & Technology Entrepreneur Parks (STEPs). At last count, there were 135+ DST-supported incubators at academic institutions and not-for profit organisations.

While the STEPs and TBIs provide space and expertise for young startups, the NSTEDB provides "financial assistance of Rs. 200 lakh to Rs. 1,000 lakh under a seed support system to appropriate and suitable TBIs/STEPs". The goal is to provide eligible qualifying startups with the financial backing (seed support in the form of equity/loans) they need to grow to a stage where they can be considered for funding by venture capitalists.

At a policy level, the DST has played a key role in getting incubators and startups at these incubators (with an annual turnover of less than Rs 50 lakh) exempt from taxes like the GST. Further, incubators can hold equity in the startups that they incubate, which was not allowed until a few years ago. The DST was also instrumental in ensuring that organisations could use their corporate social responsibility (CSR) funds to deploy into government-approved incubators mentoring social impact ventures.

The DST also partners with industry players such as **Intel India, Texas Instruments, Boeing and Lockheed Martin** to scale up the innovation value chain by helping Indian startups get exposure to international innovation ecosystems.

It also works with AnitaB.org to encourage and support women's entrepreneurship through the Women Entrepreneurs Quest (WEQ). The 10 winners of WEQ receive an all-expenses-paid experiential learning trip to Silicon Valley in US. During this trip, winners get to participate in training sessions and deep-dive workshops, interact with role models, build a network, and receive value-added guidance and inspiration from some of the best entrepreneurs, investors and mentors in the valley.

The DST also supports the **Women Startup Program (WSP) by the NSRCEL at IIM Bangalore,** along with global investment bank Goldman Sachs. The WSP announced the selcoection of 100 women entrepreneurs in May 2018. Selected participants will receive a fellowship of INR 30,000 per month along with a prototype development fund to help kick-start ventures from the DST. The top 10 female entrepreneurs will also be provided with the opportunity to go on a startup study trip to Israel.

As **Dr Anita Gupta, Scientist – G /Adviser and Associate Head – National Science & Technology Entrepreneurship Development Board (NSTEDB)** at the DST says, "Developing a new class of 100 women entrepreneurs, under the Women Startup Programme, will go a long way in empowering women for entrepreneurship and contributing towards nation-building."

In all, the DST focuses on providing support via business and technical incubation and mentorship, as well as investments via grants, fellowships and investments.

The Defence India Startup Challenge

The Defence India Startup Challenge, in partnership with Atal Innovation Mission (AIM), is an open call to all startups and MSMEs recognised by the Department of Industrial Policy Promotion (DIPP), as well individual innovators, to tackle and solve some of the most crucial technological issues faced by the Ministry of Defence. It is a part of iDEX (Innovation for Defence Excellence) scheme launched by Prime Minister Narendra Modi in April 2018 - an effort to indigenise all the defence requirements of the country, essentially making it self-reliant

The vision of the Defence India Startup Challenge is to help develop functional prototypes relevant to national security, thereby building an ecosystem of innovation in the Indian Defence Sector. It is also to find markets for relevant deep-tech products and commercialise them.

The Defence India Startup Challenge was formally launched by **Defence Minister Nirmala Sitharaman** in Bengaluru on August 4, 2018, at its launch event co-hosted by 91Springboard - a renowned co-working space chain.

During the launch, 11 challenges were presented to interested applicants, encouraging them to submit their prototypes or commercialisations. (The Ministry of Defence is yet to announce the shortlisted applicants.)

The challenges

- Individual Protection System (IPS)
- See-Through Armour
- Carbon Fibre Winding (CFW)
- Development of 4G/LTE-based Tactical Local Area Network
- Active Protection System (APS)
- Secure Hardware-Based Encryptor Device for Graded Security
- Artificial Intelligence in Logistics & SCM
- Unmanned Surface and Underwater Vehicles
- Remotely Piloted Airborne Vehicles
- Development of Advanced Technology-based Water Purification System
- Laser Weaponry

Applicants with capability, intent, and promise while prototyping or commercialising existing prototypes are eligible to receive grants of up to Rs. 1.5 crores, strictly on a milestone basis. The incentive is a part of the Defence Innovation Fund (DIF) and will be awarded through the Defence Innovation Organisation (DIO, a non-profit company formed in 2017, headquartered in Bengaluru, and funded by Defence Public Sector Undertakings (DPSUs) Hindustan Aeronautics Limited (HAL) and Bharat Electronics Limited (BEL).

Additionally, a support framework - SPARK (Support for Prototype & Research Kickstart in Defence) - to enable startups to participate in the challenge and call for proposals to address specific technological requirements of the Indian defence establishment, was also launched.

What India's Deep Science sector needs: new ideas, deep investment strategies, and a long-term vision

Deep science may be the sector to watch for in the next few years, but its success in India largely depends on industry and investor participation.

Imagine a cement mix that can heal itself when cracked. Or what if farmers could use drones to monitor their fields, and use IoT-enabled sensors for irrigation purposes? All these innovations are possible through deep science projects. But despite several startups coming up in this sector, investments are not really flourishing.

Most funds continue to focus on businesses based on internet commerce or related areas, neglecting the true innovations being put forward by India's academic institutions, scientists and researchers.

But there are a few investors who have a dedicated interest in deep science and can help pave the way forward.

One of them is **Vijay Shekhar Sharma, Founder and CEO of Paytm.** Along with venture capitalist **Shailesh Singh,** Vijay Shekhar Sharma launched a $150-million environment protection-focused fund called Massive Capital in June 2018. Vijay believes in investing for the long run and aims to back green cities, clean food, a carbonless future, less plastic pollution, clean energy, and forest restoration.

"The current generation owes it to youngsters to leave behind a less polluted, healthier environment. We need the brightest funds and adequate capital or economic resources to tackle the massive problem of pollution we are staring at," he says. "If you're serious about change in this country, we have to make sure it has an environment in which we can live sustainability and that involves long-term capital obligation," he adds.

Vijay Shekhar Sharma believes we need to increase awareness levels and hone homegrown solutions, and that small investments will support these ideas and accelerate their development to bring about a change for the future.

"India is a growing economy and we can't blindly adopt techniques of a developed economy. We have to have a context of growth and do a balancing act unique to the country," he says. Vijay wants the ecosystem to support itself. He explains, "We want to be supportive from the incubating level to late stage, with the intent to champion those who can bring these changes at massive scale. And, investments have to be more than money; it is also about having a support ecosystem with people working together."

But despite the backing from top guns like him, deep science startups remain a niche segment in India. And though the government and academia are keen, the industry continues to be wary of participation.

According to **Siddharth Pai, Founder and Managing Partner of Siana Capital**

Management, the most distinguishing feature of deep science businesses is the freedom to create an intellectual patent around the business; that gives a sense of security. Siana is a $100 million VC fund focused on investing in deep science startups.

“Industry participation is critical as any such alliance with startups will give them a wider reach,” he says.

Siddharth adds that investor interest in the sector is still nascent. He says, “While the government has done much to encourage scientific and deep technology innovation, private industry and finance are yet to wake up. That said, angel investors are now beginning to get active in this space.”

So, why is it important to invest in deep science projects? Siddharth Pai explains, “The only thing that sets a country apart is its ability to innovate. Deep science and deep tech are driven by innovation and invention, which is the watershed of progress.” He hopes that the pairing of these startups with firms like Wipro and TCS may change the face of deep science venture investments in India.

One of the earliest stakeholders of the sector is **Endiya Partners,** a specialist technology venture capital firm of India. It invests in technological and medical startups that have the potential to put their products into the global market. In 2016, Endiya raised $15 million in its first round of funding to make investments in startups across technology, consumer internet services, and healthcare sectors.

So far, it has invested in **AlphaICs, DarwinBox, SigTuple, ShieldSquare,** and others. Although focused on the healthcare industry, it looks at companies that use special technology of high interest.

With a huge repository of talent and ideas, India can make huge inroads into the global deep science startup ecosystem. No wonder experienced entrepreneurs are also betting on deep science.

Binny Bansal, Co-founder and former CEO of Flipkart and serial entrepreneur, has made several investments in early technology companies, including **Pandorum Technologies and Ather Energy.**

It seems certain that the next wave in India’s startup story will be driven by deep science, by companies offering deep technology applications and a strong product. The change – from consumer-driven ventures to innovation-focused ones – needs to be backed by the VC ecosystem.

Paytm founder and Deep Science investor Vijay Shekhar Sharma

C-CAMP: India's hub for disruptive Deep Science innovations

C-CAMP has differentiated itself as a centre for fostering deep science research and innovations that have the potential to create a lasting, global impact.

In the past decade, a quiet yet powerful revolution has been taking place in the Indian life sciences space. And nowhere is it more evident than at the **Centre for Cellular and Molecular Platforms (C-CAMP),** a government-backed agency that has emerged as the innovation hub for disruptive and globally relevant deep science research and development.

C-CAMP, which is an initiative of the Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India, was launched in 2010 to enable cutting-edge life sciences research and innovation in the country and serve as a bridge between the academic community and the industry.

But unlike other incubators or accelerators that pride themselves in offering the space and resources necessary for budding entrepreneurs, scientists and engineers in the biotech sector, C-CAMP differentiates itself by going a step further - fostering only those innovations that have the potential to be disruptive and create a deep impact on the society through globally competitive inventions.

That explains why the selection process, conducted by a team of experts that C-CAMP meticulously puts together, is extremely rigorous, with C-CAMP choosing to bet on only those ideas that appear the most disruptive and impactful. In fact, there have been many instances where the selection team has not shied away from saying no to what they view as "obvious" or "incremental innovation" ideas.

Indeed, C-CAMP prides itself on the fact that all the 110 startups currently working side by side at its laboratories and facilities are attempting to create solutions that will have a lasting societal impact – not just in India, but across the globe. These startups are building innovations to address problems in a variety of areas – from maternal and child health, to early prevention and diagnosis of various diseases, to therapeutics. Bugworks, Coeo Labs and Pandorum Technologies – featured earlier in this report – are both incubated at C-CAMP.

C-CAMP's Bengaluru centre is located alongside the National Centre for Biological Sciences (NCBS) and Institute for Stem Cell Biology and Regenerative Medicine (Instem). Together, these three institutes make up the **Bangalore Life-Sciences Cluster (BLiSC),** which aims to develop best practices for inter-institutional collaborations in India.

Today, C-CAMP has established itself as a major hub for technology resources for life sciences research and a site for interfacing with the industry, academia, government bodies, and cross-border agencies. It receives funding and support from the DBT, NCBS, Biotechnology Industry Research Assistance Council (BIRAC), Atal Innovation Mission (AIM), NITI Aayog, inStem, and the Ministry of Micro, Small and Medium Enterprises (MSME), Government of India.

With the support of the government, the agency not only provides high-end technology resources needed for the initial research and development phase, but also provides holistic support to entrepreneurs - from incubation to funding, training, mentoring to developing go-to-market capabilities. As such, it has now become a major attraction for aspiring biotech ventures engaging in disruptive innovations.

These include ventures such as biotechnology firm Aten Porus Lifescience, which focuses on drug discovery for rare and orphan diseases, med-tech firm Coeo Labs, which has developed VAPCare to prevent Ventilator Associate Pneumonia, and bio-energy company Sea6Energy, which is developing an end-to-end solution to replace fossil fuels – just three examples out of the myriad other such deep science startups at C-CAMP developing globally competitive solutions.

“This is real deep science. You’re not just doing incremental innovation. And that’s why we don’t call ourselves an incubator who gives space, but we actually work with entrepreneurs to even change their perspectives of what innovations need to be done,” says **Dr Taslimarif Saiyed, CEO and Director of C-CAMP.**

C-CAMP is now looking at replicating the success it has seen in fuelling the biotech innovation space in the agriculture sector.

In 2018, C-CAMP made its foray into the agriculture sector, collaborating with the University of Agriculture Sciences-Bangalore (UAS-B) to establish the K-Tech Agri Innovation Centre, Karnataka Start-up Advancement Programme (K-SAP-Bio 50) and the K-Tech Technology Business Incubator. Through these initiatives, C-CAMP will provide funding, incubation and deep-dive mentorship support to early-stage companies developing innovative solutions to benefit the farming sector. In 2017, C-CAMP also won the National Entrepreneurship Award from the Government of India. The National Entrepreneurship Awards was set up by the Ministry of Skill Development and Entrepreneurship (MoSDE) to boost entrepreneurship in India.

Inside a lab at C-CAMP

Bangalore Bioinnovation Centre: a premier bio-incubator for better healthcare

Bengaluru-based BBC is possibly the biggest bio-incubator in India and is helping startups working in the areas of life sciences, agriculture, pharmaceuticals, nutrition, food and healthcare

The Bangalore Bioinnovation Centre, or BBC, was set up in 2015 to nurture startups in the areas of life sciences, agriculture, pharmaceuticals, nutrition, food, environment and industrial biotechnology and healthcare.

It also helps companies working in the field of medical devices, diagnostics, and bio-pharma.

An initiative of the Department of Biotechnology, Government of Karnataka, the Bangalore Bioinnovation Centre is funded by the Government of India and today, it is possibly the biggest bio-incubator in the country.

Managing Director Dr Jitendra Kumar says the aim of the bioinnovation centre is to help companies working in the field of "deep science that powers innovation and application, that can be scaled commercially."

Spread across an area of 50,000 sq. ft in Bengaluru's Electronic City, the bioinnovation centre offers each incubatee 200-600 sq. ft space, and laboratories can be extended to make bigger spaces. Interestingly, not just the incubatees, but innovators across industries and other professionals can use the facilities on offer.

Some highlights of the bioinnovation centre include:

- Currently home to 30 resident incubates
- Helped 36 startups with funding through Idea2POC and Elevate
- 65 startups working from the premises
- Helped create employment for 150 people
- Incubatees have filed 20 patent applications over last two years

At the innovation centre, incubatees can study proteomics, cell culture, cytology, molecular biology, biochemistry, imaging, fermentation, modern biology experiments, and histopathology.

Startups incubated by the centre are selected by a 13-member selection committee that includes academicians, industry experts, professors, and CEOs of various companies. The committee is chaired by the Principal Secretary.

Cutting-edge work

Some of the notable innovations from the BBC include:

- A medical mobile-based device that can determine various parameters of blood such as proportion of different ions – salts, potassium, triglycerides - in one shot with a drop of blood.
- Artificial stem cell-generated cornea, which can then be transplanted to cure blindness.
- An early detection method for diabetic neuropathy

- Phytoceutical-based ointment to cure skin disease like psoriasis
- Artificial intelligence-based system to screen for cervical cancer
- Artificial intelligence-based hand gloves to detect neurological disorders,

Promoting deep science in India

The Bangalore Bioinnovation Centre not only offers startups space, but also helps with funding, and provides manufacturing facilities to help achieve scale. Most startups working in the area of deep science face the problem of scaling up beyond the laboratory level as most need production facilities that offer quantities much larger than at the lab-level, but much lower when compared to the industrial level.

Another major challenge for deep science startups is funding. There is limited early-stage venture funding available in the country for bio-tech startups which, most time, require funds in the range of Rs 2 core to Rs 5 crore.

So far, most investors have not been keen on the space due to lack of subject expertise, and also as investments in the bio-technology sector are risky. To address these issues, the Government of Karnataka created a fund - KITWEN Biotech Fund – in 2016-17 and it has so far funded two to three companies. Dr Kumar says funding is an organic process, and as more and more startups are created, a greater impact will be created, and it will automatically attract more investment.

Incubation centres such as the BBC, he says, create an interface or a platform where venture capitalists can see the projects that startups are working on to fund them. They can interact with startups on a monthly or quarterly basis, and, “We need to invite big international agencies such as the Bill Gates Foundation and WHO – as the healthcare products created have a very large social impact - so a robust platform can be created,” says Dr Kumar.

The BBC holds its annual flagship event, Bangalore Tech-Summit, and Dr Kumar says there was a need for frequent discussions between governments and investors. Also, more startups should come up to showcase their technology and products. “The larger the cluster, the greater the attention.”

He also says more such hubs should be created in every state and universities and educational institutions should play a bigger role. “India is a unique country with each state having some specialisation. State governments can take a lead to start with their strong points. For example, Assam has Muga silk, Bihar is strong in agriculture and can help create fruits and preservation techniques or even methods to reduce post-harvest losses. Punjab produces wheat and Kerala produces spices.”

The Karnataka model, he adds, may not be replicated everywhere because some of the country’s premier institutions like IISc, NCBS, University of Agricultural Sciences are based in the state. “Same with Hyderabad, which has taken the lead in genetic engineering”.

There is little access to good healthcare access in Tier II cities and beyond in India and innovative solutions by startups incubated at

Incubation centres such as the Bangalore Bioinnovation Centre create an interface or a platform where venture capitalists can see the projects that startups are working on to fund them.

The Bangalore Bioinnovation Centre campus

the bioinnovation centre could bring healthcare to everyone's doorstep. It could also bring down the cost of treatment, and data generated can be sent to super-speciality hospitals.

The Bangalore Bioinnovation Centre helps here in aiding startups to bring accessible healthcare to Indians beyond Tier I cities. Also, innovation in the agricultural sector can reduce post-harvest losses, and harness optimisation of resources so that farmers get better returns.

Dr Kumar says innovations in areas of medicinal plants and other herbal remedies can solve healthcare problems such as malnutrition. Strengthening agriculture along with traditional knowledge can prevent lifestyle diseases.

"Right now, the pipeline of entrepreneurs in bio-tech is narrow as compared to other countries and the population of our country. Most of these startups are being started by ex-industry professionals who have worked in labs or bio-tech or pharma companies such as Dr Reddy's or Biocon. It's good they are using their expertise to power solutions, but young minds should develop more," says Dr Kumar.

Some of the incubates at the Bangalore Bioinnovation Centre include:

- Indoor Biotechnologies
- Jubeln Lifesciences
- Omix Labs
- Lab4Life Bio Research Pvt Ltd
- String Bio Pvt Ltd
- TerraBlue XT (P) Ltd
- Jana Care Solutions Private Limited
- Innov4Sight
- E2E Biotech
- Tojo Vikas

IKP EDEN: cultivating scientific research in academia for adaptation into startups

The hardware startup incubator that champions cutting-edge work in the Deep Science space has enabled non-dilutive funding for over 175 startups and incubation of more than 120 startups.

Novelty in innovation, team strength, willingness to be flexible – these are the qualities IKP EDEN looks for in a startup in order to take it under its wing.

The Bengaluru-based incubator and makerspace is working towards creating opportunities for hardware startups. Located in the bustling locality of Koramangala, IKP EDEN was set up in September 2015 and is spread over an area of 25,000sqft. It also has centres in Jalahalli (Peenya), Mangalore, Mysuru and Belgaum.

IKP EDEN's partners include

- Department of Science and Technology, Government of India
- Department of Biotechnology, Government of India
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
- Citrix R&D India Pvt Ltd
- Harman Connected Services Corporation India Pvt Ltd
- Ericsson Global Service India Pvt Ltd
- Zinnov Management Consulting Pvt Ltd

IKP EDEN caters to around 50 startups, accommodating nearly 250 to 260 people. It offers its incubatees a combination of facilities including mechanical engineering (CNC, lathe, milling, welding, hand tools), biotech and chemistry lab, 3D printing (SLA, FDM), injection moulding, laser cutting, and the usual offering of office space, meeting rooms, etc. As of 2019, IKP EDEN has also made investments in 4-5 startups.

Focused on helping hardware startups, the incubator's strength lies in its mixed offering - a combination that might not be available in a single department of an institute anywhere. **Vikraman Venu, CEO, IKP EDEN,** says, "The greatest thing about IKP EDEN is the community and the freedom given to startups. This is the largest and densest collection of hardware startups in India. And you have access to a wide range of equipment, which would only be available if you included all departments in an engineering college."

Promoting Deep Science in India

A large part of IKP EDEN's portfolio is in the arena of Deep Science, whether it is the IKP Knowledge Park (registered in Hyderabad) or its Bengaluru centre. While the former aids biotech and chemistry startups, the latter focuses on hardware startups. But at the core of both the initiatives lies the idea of developing and promoting Deep Science.

"Research and development related to polymer science, plastics, biomarkers, molecular diagnostics, nanomaterials, microfluidics, agri-tech, food processing, advance machine learning and artificial intelligence, computer vision, electric vehicles, battery technology, or

industrial automation includes Deep Science," says Vikraman.

When it comes to Deep Science and accounting for its socio-economic impact, innovation is the key. And innovation happens at the intersection of multiple disciplines, according to Vikraman, who deems basic science essential for technology-based innovation.

"Without basic science, there will be no new applied science-based technologies; you may not have ground-breaking innovations in the space of agriculture, health and possibly in education, all of which are key to socio-economic development," he adds, explaining the correlation between the basic tools of science and Deep Science and the overall impact in the startup ecosystem.

IKP works with DST and DBT, the Government of India, the Bill and Melinda Gates Foundation, USAID, DFID-UK, and Government of Karnataka to enable grants or non-dilutive funding for startups and innovators. So far, IKP has enabled non-dilutive funding for over 175 startups and physical incubation for more than 120 startups. With a large number of initiatives striving towards success (in the biotech, health and agri space), however, this startup incubator hopes to spawn a new era of Deep Science-based startups. "Success will breed success and investments will follow. We manage grant funds for several organisations, adding up to over Rs 150 crore, given to startups. We have recently got into angel investing," he adds.

Deep Science at the grass root level

To nurture quality in Deep Science is to instil the idea at the grassroot level by educational institutes through means of basic sciences. While incubators honing startups put their best foot forward, one cannot deny the fact that there are certain challenges facing science in India:

- Lack of research infrastructure to pursue basic sciences
- Lack of funding
- Lack of academic willingness and patience to pursue basic sciences.

Given the situation, quality educational institutes nurturing basic sciences is imperative. Vikraman explains, "The startup ecosystem tends to focus on monetary gains and in this time is a serious commodity. Basic science research needs to be cultivated in academia, and later adapted into the startup world."

Cutting-edge work

PathShod, NanoSniff, Inito, Remidio, Predible, AIndra, Hyperverge, Emflux Motors, Ossus Biorenewables are amongst the many incubatees benefitting from IKP EDEN. From teams working on gene editing to bioprinting to those using AI for various industrial uses, the hardware startup incubator is working towards cultivating a diverse breed, some of whose notable innovations include:

- Work on advance optics and AI systems for point-of-care testing (Inito and Remidio).
- Use of MEMS and nanosensors for medical diagnostics (PathShod and NanoSniff).
- Work on advance machine learning and AI for healthcare (Predible and AIndra) and industrial applications (Hyperverge).
- Use of nanomaterials for water purification (Ossus Biorenewables).

- Development of a platform for tokenising the drone regimen in India (Skylark Drones, one of the most successful drone companies in the country).
- Work on creating a first-of-a-kind electric superbike, which is expected to break all speed records for electric vehicles (Emflux Motors).
- Work on electricity-free refrigeration systems, which was part of IKP's accelerator programmes (Coolar, a German startup).

Although the Bengaluru-based incubator does not have a cohort system (for incubation), they run two accelerator programmes - one focused on social impact and the other focused on medical devices. The medical device accelerator was in partnership with UC Berkeley - Innovation Acceleration Group.

What makes IKP EDEN different from the other incubators in the state as well as in the country is that it's a free system, open to everyone irrespective of affiliation. It is also private and not associated with one single academic institution, says Vikraman, explaining that the hardware startup incubator offers the widest range of research infrastructure that is not available anywhere else.

"We manage grant funds for several organisations, adding up to over Rs 150 crore, given to startups (over 175 funded). We have recently got into angel investing," he adds.

The IKP-EDEN team at the inauguration of a new campus

The Indian Institute of Science, Bengaluru

IISc's Society for Innovation and Design: nurturing differentiation and disruption

One of the most prestigious scientific institutions in the world, the Indian Institute of Science (IISc) has been home to some of the most brilliant scientific minds of India. Housed in a lush green campus and equipped with state-of-the-art research facilities, IISc is also nurturing a number of deep science-based startups.

In 1991, the Society for Innovation and Design (SID) cell was set up in collaboration with IISc to help businesses harness the rich and diverse repository of talent, knowledge and ideas of the institution. It has three divisions – CORE, TIME and STEM.

STEM is the cell's incubation wing, which has been helping many young minds bring their innovative ideas to life. It has incubated over 22 startups so far, each with an idea that has the potential to disrupting our status quo: Astrome, for instance, is working to provide broadband internet using a constellation of satellites in low-earth orbit. Bellatrix Aerospace is cutting the cost of putting satellites in space. Openwater has a low-cost solution that converts wastewater into potable water and can be used by small communities.

We caught up with C S Murali, Chairman of the Entrepreneurship Cell at SID, to talk about the deep science startup ecosystem in India and its sustainability. Here are edited excerpts from the interview.

YourStory: Why don't we see as many startups in the area of deep science as in other fields?

C.S. Murali: An entrepreneur would not require much of a capital to roll out their idea if it's not a hardware-based innovation or product. The best part about non-deep science startups is that an entrepreneur can fail quickly but come back with the modified version of the product within no time.

But, when it comes to a hardware-based product, the capital and time required to execute even a beta version are comparatively high. You cannot attract customers by saying that you will offer them a phone worth Rs 10,000 at Rs 8,000, but you can surely attract the same customer with a price tag of Rs 2,000.

The only way you can sell the phone at that low a price is by doing something different. **In short, it must be highly differentiated from the existing ones, which can happen only through science.** Things are changing. The budding startup ecosystem in India is witnessing the growth of start-ups in deep science.

YS: Tell us more about this evolution.

CSM: A startup is not a research venture, but a business venture. For all the right reasons, people have realised that if the idea works out well in deep science hardware innovation, then an entrepreneur can scale heights. You can succeed if you can develop a phone with the best specs but at one-tenth of the costs of currently available phones in the market.

Social impact is also one of the top reasons for the rise in deep science startups. In today's generation, people run to the hospital at the drop of a hat for various check-up, tests, and

MRI scans. Where does this equipment come from? Big brands aren't cost-effective and are only present in hospitals that can afford it. Additionally, you also have to spend on training healthcare officials to operate these machines.

Large manufacturers of healthcare equipment with strict deadlines are restricted when it comes to innovation, whereas startups have the liberty to innovate. In fact, many startups in India are in the process of manufacturing healthcare devices, which cost merely one-tenth of the equipment available in the market. Further, these demand minimal training when it comes to using them.

The equipment is designed to last longer and require next-to-no qualifications to operate and can sustain on a low battery in rural regions. Such designs are addressing the need of the hour for the country, letting upcoming entrepreneurs venture into hardware-driven innovation through science.

For example, we know India is called the 'diabetes capital of the world' and many diabetic patients have a glucometer at home. These glucometers are not only inefficient but also not the right method to check sugar levels. The machines also require periodic maintenance and cost at least Rs 3,500.

To address this issue, a young startup Pratishod has made a diabetes management device that helps you check your (blood) sugar level. Based on seven new patents, Pratishod's device costs one-third of the current equipment available in the market. Also, customers can test their sugar levels at any point in time with ease.

YS: What do you think of the entrepreneurs venturing into deep science?

CSM: To understand present trends and behaviours, and to address it through extensive research in science, one requires people with intense knowledge. This is another reason why deep science startups are in low numbers compared to startups in the software region.

Understanding the potential and calibre of such minds, corporations like Microsoft and GE have been hiring these people in their R&D sectors to scale innovations and create new technologies.

YS: Is a lack of investors and funds is also hindering aspiring entrepreneurs from entering this space?

CSM: The fact is that many investors look at early returns and avoid risks. But deep science demands high risks are taken and time is given.

There are two aspects to consider. First, angel investors are reluctant to invest the desired amounts. Second, many investors will only invest in startups they understand.

On the other hand, venture capitalists bring in large sums of money only when a company has a revenue model. To get VCs on board, one requires substantial market presence and a growth structure. Some venture capitalists tend to focus only in those areas that they have knowledge about, like retail, ecommerce and semiconductors, because of the expertise they have in these areas.

YS: There are many government organisations already in the field with large-scale research. So how does a deep science startup like Bellatrix compete with the likes of DRDO Labs and ISRO?

CSM: Many of us don't know the fact that, like any industry, ISRO also outsources some of its necessities.

In recent years, ISRO has taken Bellatrix under consideration for some of its vital components. This is the first time that a startup has been considered over the large corporations who have been supplying the required resources to ISRO so far.

Only Indian companies can build things for a better India, be it in healthcare or space. With the tremendous competition, India cannot rely on foreign players to address its requirements. Then, it becomes necessary for DRDO and ISRO to encourage smaller players to participate in this domain.

YS: How is the government helping people to pursue their ideas in this?

CSM: The Department of Biotech has granted funds up to Rs 60 lakh to various biotech startups. Now, the government is also stepping in to facilitate these budding startups. But it needs to speed up the process as these deep-science startups are in dire need of support with the foreign competitors stepping up their innovations.

YS: Do you think deep science startups will be on the rise soon?

CSM: Deep science startups have been here for a long period of time. I believe there is a considerable lack of media coverage of these start-ups. Researchers end up going either into research and development centres of major companies or continue in academics. Other than these two types, there is a third type – a small number who choose to become entrepreneurs.

Decades ago, the West was the market for the world, but now, it's moving towards the East. Now, India has become the largest consumers of outsourced products. This should encourage young budding entrepreneurs to scale up their innovations.

Photo by Jjesse Orrico on Unsplash

Campus-based incubators encouraging startups at the intersection of sci-tech

IIT - BOMBAY SINE	IIT-Delhi FITT	IISc SID
Mumbai	New Delhi	Bengaluru
FOUNDED IN 2003	FOUNDED IN 1999	FOUNDED IN 1991
INCUBATED STARTUPS: 74	INCUBATED STARTUPS: 35	INCUBATED STARTUPS: 200
AREAS OF FOCUS	AREAS OF FOCUS	AREAS OF FOCUS
Conversion of R&D into entrepreneurial ventures	Promotion and sustenance of commercialisation of science and tech for mutual benefits	Converting scientific knowledge and technology into a practical and valuable form

IIT-KANPUR SIIC	IIT-MADRAS INCUBATION CELL	MANIPAL UNIVERSITY TECHNOLOGY BUSINESS INCUBATOR
Kanpur	Chennai	Manipal
FOUNDED IN 2000	FOUNDED IN 2013	FOUNDED IN 2010
INCUBATED STARTUPS: 24	INCUBATED STARTUPS: 154	INCUBATED STARTUPS: 25
AREAS OF FOCUS	AREAS OF FOCUS	AREAS OF FOCUS
Green IT, clean energy, smart materials, affordable healthcare, water and sewage management	Skill development, legal and compliance, robotics, energy, renewables, agritech, edtech, biotech, healthtech, rural ventures, AI	Healthtech, agritech, alternative IT, green IT


33%
18.5%
22.9%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
YOURSTORY